Price One Shilling.

RUDIMENTARY TREATISE

ON

AGRICULTURAL ENGINEERING

BY

G. H. ANDREWS,

Agricultural Engineer.

VOL. II.

MOTIVE POWERS,

AND

THE MACHINERY OF THE HOMESTEAD.

LONDON: JOHN WEALE.

RUDIMENTARY TREATISE

ON

AGRICULTURAL ENGINEERING

With Illustrations.

BY

G. H. ANDREWS, C.E.

VOL. II.

MOTIVE POWERS AND MACHINERY OF THE STEADING.

LONDON:
JOHN WEALE, 59, HIGH HOLBORN.
1852.

LONDON:

BRADBURY AND EVANS, PRINTERS, WHITEFRIARS.

CONTENTS.

INTRODUCTION.

In the first division of this elementary work on Agricultural Engineering, everything which related to the arrangement of farm-buildings, was therein stated, so far at least as the limits of so small a work permitted; and the succeeding considerations in the present volume, will especially refer to the machines and implements used in connection with the farm-steading generally.

Until within a few years, no machinery was regularly employed in the homestead; all was done by hand—aided, it is true, by a few rude tools—and in many districts of England, at this time, scarcely a single machine will be found in use; and it is only now in a very few farms that any regular system of mechanical arrangements exist for performing all the home operations, with the economy and superiority that a regular set of the most approved machines will do. Certainly, one or two machines may be found on almost every steading; but they are improperly fitted up, and generally, if examined, will be found to be in a very bad state, and consequently, not half the advantage is obtained from them that would be gained if they formed part of a regular system, properly set up.

Farmers, generally, are ignorant of the principles of mechanics, and of the ordinary details of mechanical contrivances; and until they become better acquainted with them, the general introduction of arranged machinery will

not take place; for they will not buy machines until necessity drives them to do so, and when they do, it is ten to one but out of the large and beautiful assortment they have now to select from at agricultural shows, and elsewhere, they will choose one of the very worst; and that, from this simple cause—that they are not good judges of the things they buy. That this is the case, and the opinion of those who make these machines, is proved by the manner in which they try to attract and deceive the farmer, by painting the machine of the most gaudy colours,—the brightest reds, blues, greens, and yellow. This painting and decorating is only to hide the rude workmanship and bad materials, that would be evident to the most unpractised eye, unless so covered up. I do not mean to say that this is now the case nearly so much as formerly, or that it is done by the large, leading firms; but, nevertheless, wherever such things are congregated, a large number would cut but a sorry figure, if exhibited in their naked worthlessness. No attempt to deceive in this manner is made by machinists, in supplying plant to manufacturing concerns, where machinery is much employed; and for the very simple reason, that the manufacturers who employ them have taken the trouble to learn something of the principles and construction of the things used; therefore they are not so easily deceived, being much better acquainted with mechanics.

Farmers must endeavour to put themselves in the same position; for now that so large a portion of their business is performed by the aid of machinery, it is positively necessary that they should become acquainted with the principles and construction of mechanical contrivances; and this is by no means so difficult a matter as they would at first be likely to imagine.

The various contrivances for giving motion to the different parts of machines are nearly all alike. The peculiarity of the machine will usually lie in the arrangement, or some

peculiar part to which motion is given, for executing some particular description of work. It will not be difficult, then, for the farmer to make himself acquainted with the proper manner in which these ordinary points should be arranged with reference to each other, and the marks that would indicate good or bad materials and workmanship.

If I have complained of the farmers' want of knowledge of the science of mechanics, I must certainly also state, that a great many of the makers of agricultural machines are equally deficient; for worse designs, and more bungling contrivances, could not be found, than may be met with at agricultural shows, and other places, where a large quantity of machines and implements are exhibited; and this is caused by a great number of small people, mere wheelwrights, or, at most, local plough and harrow makers, attempting to construct, without tools or the knowledge necessary, agricultural machines, whose efficiency is dependent entirely upon the accuracy with which the various working parts are fitted up. These people often tempt the farmer, by asking a somewhat lower price than the first-rate makers, and he buys their paint-bedaubed libel on the real machine, carries it home, and gets it to work, when, to his surprise, it fails to do the work anticipated. After a few trials, it is thrown aside; and he, and the rest of his neighbours, set their faces against the use of machinery, to their own injury, as well as of the community at large.

I do most especially advise all those who are about to purchase the more expensive class of implements, more particularly barn machinery, of all kinds, to go to a first-rate house for what they require, and to pay a proper price; though I am sorry to see some *large firms*, who should know better, condescend to make things of an inferior quality for those who *will* cheapen.

The workshops now of the eminent makers are, in every respect, equal to those of the great engine manufacturers and

machinists. They possess the same plant and tools, for executing their work with mathematical accuracy, despatch, and studied economy. Large capital enables them to purchase materials at better and cheaper markets; character is a guarantee that they will sell that only which is what it represents itself to be. These houses, I am glad to see, are getting rid of the gaudy-coloured paints. Mr. Crosskill has exhibited all his implements and machinery at the Great Exhibition in Hyde Park, without paint of any kind,—a practice which, I am glad to see, is being imitated by many others. Messrs. Barrett & Exhall painted everything a simple lead colour; and these two stands far exceeded in appearance any others in the place.

What I have said in reference to the inability of small makers to compete, either in price or quality, with the larger firms, I do not intend to apply to the smaller implements, such as ploughs, &c., as it is quite possible that a man of superior intelligence may, from having devoted his time and ability to the perfecting of one or two implements, equal, or even surpass, the large firms in the design and workmanship of such implements. The best ploughs do not usually come from them; neglect is observable—the attention being taken up with machines of a more expensive character (though here we must except Messrs. Howard, of Bedford, and Messrs. Ransome, of Ipswich).

I think it is an admirable plan that has been adopted by Messrs. Deane, Dray, & Deane, of Swan-lane, London-bridge, to act as agents for a variety of makers, in different localities, many of whom have become celebrated for the perfection to which they have brought particular machines and implements. Messrs. Deane, Dray, & Co. have here collected under one roof the best of everything, from the different parts of England. Persons have been recommended to purchase through this house, with satisfaction. This firm, selling such immense varieties, can

always recommend that which is best for the particular locality and purpose that may be required. An establishment upon this plan should exist in every large town in England.

Whenever it is intended to fit up thrashing, cleaning, and chaff-cutting machines, as part of a regular system, most certainly one large house ought to be employed to execute it. This can be done by contract for the whole, and at a great reduction in price.

Machinery to be driven at high velocities, should be much better framed together, than the machines usually sold as separate machines. Where one house fits up the whole barn-work in a piece, they will have opportunities of arranging the frame-work on a much better plan to ensure steadiness of working. The same parties should always be consulted previously to the construction of buildings that are to contain the machinery, so that proper arrangements may be made for the foundations and bearings, as well as leaving the necessary apertures in the walls for the shaftings and bearings. This will save unnecessary expenses for iron and wood carriages, and framing to support the gear. The architect should always be put in communication with the machinists as early as possible, that they may agree upon the arrangement, as well as making the necessary provision for plant.

Eminent agriculturists are divided in opinion, as to whether it is better to have a fixed engine, and the barn machinery regularly fitted up in a building, and bring the corn to the machine; or to have a portable engine and thrashing-machine, and take the machine to the corn. No doubt, there is a great deal to be said on both sides; and on very large farms, with out-lying land, it is a most convenient thing to thrash in the field; and the portable agricultural engine has been so improved and perfected, as well as the large portable thrashing-machines, that field-thrashing

is, doubtless, done with great facility, and in a very perfect manner. Nevertheless, I do not myself think the system is so good as having the engine fixed, and the whole plant to form part of a regular plan. It is found in all manufacturing operations that the more concentrated the machinery, and the more all the operations are got together, and under one general management, the better it is; and I cannot see why the manufacturing manner in which farm operations are now, and must every day still more become, should be an exception to the rule; but of this it is certain, that fixed machinery, permanently fitted up, will always do the work a great deal better, and more economically, than portable machines of any kind;—that a fixed steam-engine and boiler, of judicious design, will consume a much smaller amount of fuel, and last much longer, with scarcely any repair, than a portable engine, the repairs of which will be found enormous, as compared with the fixed engine, when extending over a number of years.

I am inclined to think that the preference is given to portable engines, chiefly because of the want of properly-contrived homesteads. The work requiring to be done is distributed about, instead of being concentrated, and brought under one roof; and often there are two or more small sets of buildings in the same farm, instead of one general homestead. Under these circumstances, scarcely any other than a portable engine could be used; but when a regular system of railways is laid down to every part of the farm, and the liquid manure delivered through pipes to every field, portable engines will cease to be required, and the advantages of fixed ones of large size fully appreciated; every duty that can will then be thrown upon it, and but few days in the year will this important auxiliary of the farm be suffered to remain idle.

CHAPTER I.

THE STEAM-ENGINE.

The steam-engine is the real motive power upon which farmers will have to rely; for, although in no case where water power *can be got*, should it be neglected, yet it will be but with a comparatively small number of steadings that this power is available. Windmills as motive power are not to be thought of, and horse-gear work will only be used on exceedingly small farms.

We have no space here to discuss whether the steam-engine should be erected by the landlord or not: the general opinion seems to be that it is to be considered as a part of the ordinary dead stock of the farm, and that he will carry it from one farm to another, the same as he now does a cart or waggon. The advantage of having one is now generally admitted, so that our object must now be to lay before the farmer, in as concise a manner as possible, some account of this valuable machine, and the various forms in which it is constructed, and endeavour to point out which is the most suitable for his purpose; for, although steam-engines have been and are daily being constructed upon all sorts of plans, yet it is only a few of the simplest of these, and of such as have stood the test of experience, that can be considered at all adapted to the purposes of agricultural engines. The first steam-engines erected for performing the heavier duties of farmsteads were erected in Scotland about 1825, and are still in constant use: they were all of the condensing reciprocating description, and, though erected at a great cost,

have not deterred the enterprising agriculturists north of the Tweed from continuing erecting such and more suitable engines up the present time; and now in Scotland nearly every farm of any extent is provided with this valuable auxiliary.

As this little book is an elementary treatise, and intended for the perusal of farmers, and not engineers, it may not be out of place to describe the principle and manner in which steam is made to play so important a part; and those who have a little knowledge, as well as those who have none at all, upon the subject of steam-machinery, I recommend to peruse Dr. Lardner's elementary treatise, written expressly for this series of Mr. Weale's rudimentary volumes;—they will there find the subject treated in the simplest possible manner, yet sufficiently detailed as to give a good general knowledge of this important subject.

The mechanical action of steam is usually accomplished by a piston moving in a cylinder. The cylinder is a tube in most cases of a greater length than the proportion of its diameter.

The piston is a plug fitted accurately to the bore of the cylinder, not so tightly as to prevent its being easily slid from one end of the cylinder to the other, yet sufficiently so as to prevent the passage of steam between it and the side of the cylinder.

Attached to the piston on one side, in its centre, is a circular bar of iron, accurately turned from end to end, called the *piston-rod.*

Each end of the cylinder is closed by lids, through one of which the piston-rod passes; this is kept perfectly steam-tight by a packing of hemp soaked in oil and tallow.

A blast of steam being admitted on one side, the piston is forced onwards to the other end, and a similar blast being admitted on that side (and the means of escape being opened on the other), the piston is then pushed back to its former position; thus the primary motion produced by steam power is an alternate motion backwards and forwards in a straight

line; but by an infinite number of well-known mechanical contrivances, this alternate motion may be made to produce any other kind of motion that may be desired; thus, we may make it keep a wheel in constant rotation, or move a weight continually in the same straight line, and in the same direction. The various details by which these objects are effected, and which constitute the working parts of the engine, we will now proceed to describe separately.

First, the means by which steam is admitted into and allowed to escape from the cylinder. This requires two apertures to be made at each end of the cylinder, one for the admission, and the other for the escape, of the steam; the first must have a communication with the boiler, and the latter with the vessel where the steam is condensed, as in condensing engines, or into the atmosphere, where it escapes, as in high-pressure engines.

These apertures, or steam-ports, must of necessity require to be alternately opened or shut, which is done by contrivances called puppet-valves—those which open a communication with the boiler being called steam-valves, and those which open the communication with the condenser are called exhaust-valves.

These valves are conical discs, fitting lightly into holes, from which they are lifted or drawn, and to which they return alternately: they are made of gun-metal, with their faces ground so as to fit with the greatest precision.

In lieu of these valves an arrangement is often made for effecting the same end by what are called slides. The two openings to the cylinder in this case, being ground to a flat surface, upon these two plates or discs, also ground to a true surface, pass backwards and forwards, thus covering or uncovering by pairs the openings for the admission or escape of the steam.

The manner in which these valves act is thus: supposing the cylinder to be placed in a vertical position (which it is

not always), when the piston arrives at the top of the cylinder, two valves, the upper steam-valve and the lower exhaust-valve, are required to be opened, and at the same moment the two other valves, the lower steam-valve and upper exhaust-valve, must be closed. Now, as all these movements are simultaneous, it may be easily imagined that the four valves may be so connected that a single movement imparted to them should open one pair and close the other.

When the piston arrives at the bottom of the cylinder, a single motion in the contrary direction will evidently effect the object to be attained, that is to say, to open the lower steam-valve and upper exhaust-valve, and close the upper steam-valve and lower exhaust-valve. This will be better understood by reference to fig. 1.

Fig. 1

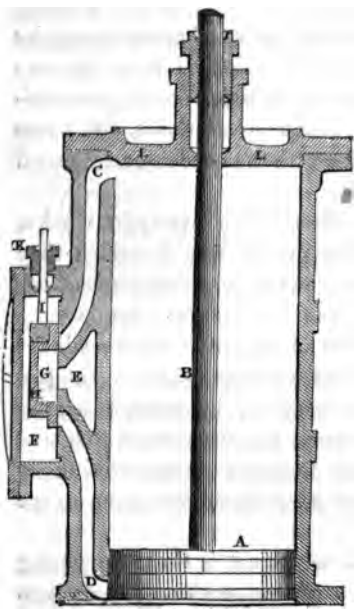
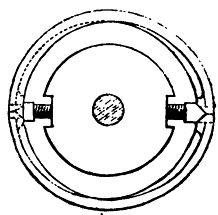


Fig. 2.

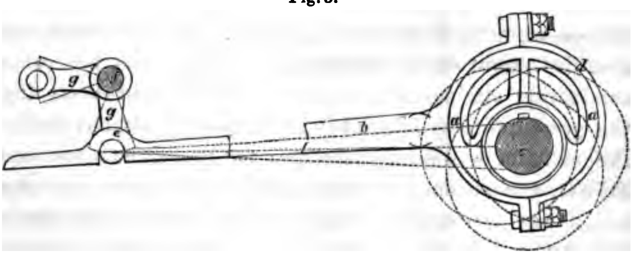


METALLIC PISTON.

To render the engine self-acting, some contrivance must be adopted by which these valves will be regularly opened or shut by the action of some part of the engine itself. In the early history of the steam-engine, a boy was employed to open and shut these valves, but they only made six or eight strokes per minute in those days. A boy so employed, named Humphrey Potter, was the first who made the steam-engine self-acting by adding what he called a scogger; that was a contrivance attached to a portion of the machine in motion, which opened and shut the valves, during which time the boy was enabled to scog or skulk. This was the origin of what is called hand-gear, and which is still attached to some large engines, but not to any likely to be used by agriculturists except for the purpose of lifting water, which will be found described in Part III. of this work.

The means generally adopted for opening and shutting valves and working slides is by what is called an eccentric, as seen in fig. 3.

Fig. 3.



This consists of a circular plate of metal, A A, fixed upon a shaft, E, at some distance from its geometrical centre. Round this eccentric point it is made to revolve, and in revolving it is evident that its geometrical centre revolving round its centre of motion will be thrown alternately to the right and left of such centre.

Round this circular disc is placed a ring, *d*, within which it is at liberty to turn, but not to turn the ring with

it; the ring will consequently be thrown alternately to the left and right of the centre on which the eccentric plate is made to turn, and the throw or length of its play right and left will be equal to twice the distance of the geometrical centre of the disc to the centre on which it actually turns. To this ring is attached a bar, *b*.

As the centre is thrown alternately right and left of *e* by the revolution of the disc, the point *e* receives a horizontal motion, right and left, to a like extent. The motion is transmitted by means of the levers, *g g*, to the slides of the cylinder by the mechanical arrangement shown in the cut.

With whatever force the piston be impelled, the effects of that force will be augmented just in proportion to the amount of vacuum produced in that part of the cylinder towards which the piston is pressing. Now, if one cubic foot of steam be reconverted into cold water, it will be reduced to one cubic inch of liquid, and we shall get the entire cubic foot (minus one inch) of vacuum, and therefore for every cubic foot of steam in the cylinder, we shall have a cubic foot of vacuum, minus one cubic inch. It is this advantage that is sought to be obtained by using what are called condensing engines, and it is to the genius of Watt that the great difficulty of condensing the steam without cooling the cylinder has been overcome; for previous to his time (1763), the steam was condensed in the steam cylinder, which was consequently cooled down at every stroke of the engine. It will not be difficult, then, to form an estimate of the enormous value of this discovery of Watt's, and the great advance made in steam machinery dating from that time, when the process by which he effected it is considered. Watt's invention consisted in the producing an almost perfect vacuum without in the slightest degree lowering the temperature of the steam cylinder, and this he effected by placing near the cylinder another vessel submerged in cold water, *and having a jet* of cold water constantly playing within it.

Whenever he desired to condense the steam in the cylinder, he opened the communication by a valve between this vessel and the cylinder, and immediately the steam, by its elastic force, rushed into this vessel and was instantly condensed, leaving in the cylinder an almost perfect vacuum, and at the same time exposing the cylinder to no cold which could in the slightest degree lower its temperature.

Now, the second vessel, or condenser, would in time become filled with water from the jet, and condensed steam, as well as air, which would enter in a fixed form in the water, and which would be liberated by the warmth of the steam condensed by the water. This air would, to a considerable extent, vitiate the vacuum in the condenser. These impediments were surmounted by the adjunct of a pump to the condenser, by which the water supplied by the jet and the condensed steam, as well as air, were constantly pumped out by an apparatus called the air-pump.

To prevent the water surrounding the condenser from becoming warm, there is placed a pump and waste-pipe—the pump for supplying cold water, which, by its superior gravity, sinks to the bottom of the cistern, and the waste-pipe to carry off the warm water which, being lighter, rises to the top. In this state did Watt leave the steam-condensing apparatus, when he died, and so it remains to this day; for it has been remarked that the history of the steam-engine ends with Mr. Watt's labours.

Having, by the means which we have described, produced a continual self-acting reciprocating action of the piston, the next thing is to apply that motion to the machinery required to be moved, and this is done by attaching it at once to a beam, called the working beam: this is supported on a fixed axis, and alternately vibrates upwards and downwards as it is moved by the action of the piston through the piston-rod.

Now, it is evident that the ends of the beam to which the

piston would be attached could not move upwards and downwards in a straight line (as the piston-rod does), but must describe the arc of a circle, whose centre would be the axis upon which the beam vibrates.

The piston-rod, as we have before described, is an accurately turned bar of iron, working through the centre of the cylinder-cover, and kept securely in that position by the packing in the stuffing-box, and unable to swerve to the right or to the left; consequently, if the head of the piston-rod was fastened to the end of the beam, it would be strained and bent by the motion of the beam. To remedy this inconvenience, it is necessary to place between the end of the beam and the top of the piston-rod a piece of mechanism called the parallel motion, which accommodates the curvilinear motion of the one to the rectilinear motion of the other. This is formed in a variety of ways; but the most common is the arrangement invented and used by Mr. Watt, and is considered one of his brightest thoughts: it is a continuation of rods, so arranged and joined together that while one of their pivots is moved alternately in a circular arc, like the end of the beam, some point upon them will be moved alternately upwards and downwards in a straight line. This will be readily understood by reference to the plate.

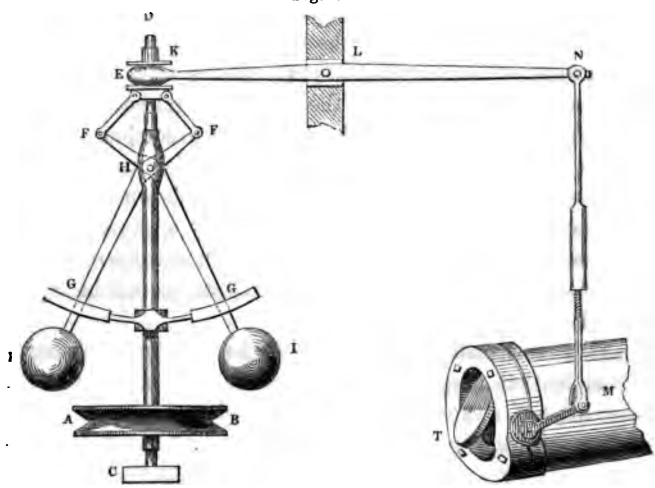
As nearly all motions that are required for driving the machinery of mills are effected by the constant turning of a wheel upon a shaft, it is necessary now to convert this reciprocating motion in a straight line, to which we have now arrived, into, as nearly as possible, a continually acting rotatory one, and this is generally effected by another invention of Watt's, called a crank. This is an application of the ancient method of giving motion to the potter's lathe, the original inventor of which is unknown, and even the era of its introduction.

The crank is an arm attached generally to the centre of

the wheel, which it turns in the same manner as the motion is imparted to a winch or windlass—a thing of such common application, that it can require no description here. As a matter of convenience, in those engines worked with a beam, there is interposed between the end of the beam and the crank a strongly formed bar of iron called the connecting-rod.

Having by the means we have briefly described now got a self-acting machine ready to apply to any purpose required, there remains only one other point necessary to be attended to,—and that is of considerable importance,—being the means by which the power we have got may be kept within bounds, when inclined to exert itself too much, or stimulated when inclined to flag; and it would be continually falling into the one error or the other, however well the machinery might be constructed, as the work it was employed to do might increase or decrease in load upon it. To remedy this defect, Mr. Watt adopted an ingenious contrivance which is now called the governor, shown in fig. 4.

Fig. 4.



A similar irregularity to the one we have described, occurred in the motion of corn-mills, from the varying quantity of water or resistance. It had early exercised the ingenuity of millwrights to obtain some means by which its injurious effects could be obviated, and the means they adopted was attaching a couple of heavy balls to a jointed rod. These balls were made to revolve by being connected with the spindle or axis of the mill-runner, and the apparatus was called a lift-tenter. The centrifugal force of these balls when in motion either raised or lowered a stage in which the arbor of the spindle revolved, and brought the stones nearer, or removed them farther from, each other, as they might require to be adjusted. This most ingenious regulator Mr. Watt applied to regulate the opening and shutting of the throttle-valve of the steam-engine. Fig. 4 shows the manner in which this is effected. I I are two balls attached to two rods H G; when the balls separate so that the rods H G become more divergent, the arms H F open, and the pivots F separating, draw down the collar E, which slides on the spindle. When the balls, instead of diverging, approach each other, the arms H F also approach each other, and the collar E is lifted. Thus, as the balls, by the action of centrifugal force, diverge or contract towards the seat they occupy when the engine is at rest, the collar E is raised or lowered by means of a lever, N L K, having a fork formed at one end, which receives the motion of the sliding collar E, and transmits it to the lever of the throttle-valve, as shown in the cut. A rotatory motion is given to the balls by a strap, gut-line, or gearing to the pulley A B (fixed upon the lower part of the spindle) from any convenient part of the machinery in motion.

As it is necessary that the boiler be supplied with water equal to that evaporated and consumed by the engine in the shape of steam, it is usual to employ the power of the engine to work pumps for that purpose. In condensing-

engines, the water is supplied to the boiler from the condenser, extracted by the action of the air-pump, as this water is considerably warmer than that drawn direct from the original source, and is of course a saving of so much heat. As this supply of water requires to be merely regulated, a self-acting apparatus is attached to the boiler, as shown in fig. 15; but this arrangement is only applicable to low-pressure boilers, as the column of water or head would require to be inconveniently high to overcome the great pressure of the steam in the latter case. Therefore, forcing or feed-pumps are attached to the engine, and an arrangement made by which the driver can regulate the quantity supplied, which he ascertains by means of the gauge-cocks, or glass gauge-tube, shown in fig. 20.

Having now lightly passed over the leading features of the ordinary method for applying the elastic force of steam to the working of machinery, we may now proceed to a description of the various and most approved forms in which the steam-engine is constructed, and the various parts we have discussed, arranged in the most suitable manner for the purposes of the agriculturist.

The Boulton and Watt condensing beam-engine is doubtless the most perfect machine, and the most economical form in which steam power can be applied, especially when to it are added some of the most recent improvements for working the steam expansively, and in two cylinders; the engine may be considered in this form, almost perfect, and I have lately had an opportunity of examining one of this description of most excellent design and workmanship, at a corn-mill at Wandsworth, in Surrey, belonging to Mr. Watney. This engine is working twenty-three hours out of every twenty-four, and doing about twenty-five horses' power the whole of that time, with seven tons of coal per week; a most excellent duty; it was manufactured by Messrs. Wentworth of Wandsworth, and does them infinite credit.

On all very large farms, where a large power can be constantly employed, I should recommend engines of this description, but as these cases must be but very few in number, something *much cheaper*, much more easily managed, and much simpler in its action must be sought for. In Part I. of this treatise I have given the reasons why I think farmers should not go to the expense of erecting such costly machinery as is used by regular manufacturers, even supposing such to be to the manufacturers a little more economical in the end. The farmer, as I have before observed, is differently placed, inasmuch as his machine is only employed for a certain portion of the year, while the manufacturer is constantly employed, almost day and night, in producing minute portions of profit. The farmer may save more in interest upon dead capital sunk in machines, than he would in the saving he might get by having them so much more expensively constructed. For agriculturists they must be made at a low price; for farmers' profits in future will not admit of the smallest amount being sunk unnecessarily in the construction of their machines, which must of necessity be expensive under any circumstances.

The high pressure beam-engine.—This is the form of engine oftenest adopted on large farms; it is constructed in much the same manner as the condensing engine before described, that is with beam parallel motion, connecting-rod, crank, and feed-pump; and is generally constructed with an iron frame supported by columns similar to condensing engines, but it has neither condenser nor air-pump. This engine is manufactured by all the leading firms, as Ransomes', Garrett's, Tuxford, Hornsby, &c.

Now, however cheaply this engine may be got up, it must be expensive on account of the number of parts employed in converting the rectilinear motion of the piston-rod into the rotatory one of the shaft. It has been, therefore, a point much aimed at by the builders of engines to get the

piston rod to act as directly upon the crank as possible, and so produce what are called direct-actimg engines; this has been done in the following different plans; first, by working a cross-head attached to the top of the piston-rod between guides, and placing a connecting-rod between the crank and the head of the piston-rod: an exceedingly simple engine has been constructed upon this plan, and it answers very well in practice. Its defect, of course, consists in the friction of the cross-heads against the guides, and the thrust and pull of the piston-rod being so much out of the straight line, as it must of necessity be by the throw of the crank. This defect gets less apparent as the connecting-rod is made longer. A variety of agricultural engines have been constructed upon this plan, with long connecting-rods and high frames.

The next method is by having the cylinder set upon a point or points in the centre upon which it is allowed to oscillate; in this case the head of the piston-rod is attached at once to the crank, and an exceedingly simple engine is produced. This ingenious method of getting rid of parallel motions, beams, and connecting-rods, was the invention of Mr. Watt, who seems to have left nothing to do by those who followed. In some books upon the steam-engine this invention is attributed to Mr. Whittie, and it certainly was brought into use by Mr. Maudslay. Doubtless the same notion occurred to Mr. Whittie as had previously occurred to Mr. Watt; that he invented and made a working model of it there is no doubt, for at the Great Exhibition in Hyde Park, upon the frame of the Great Boulton and Watt Marine Engines, there was placed by that firm the identical model, made by McMurdoc, at Soho, 1763. The cylinder case was of wood, and the model very roughly got up; nevertheless, the oscillating engine was perfect; the action of the slide was arranged in the same manner as it is commonly worked now, and the engine was in appearance the

ordinary oscillating engine of the present day. It being my duty to report upon agricultural and other machines for the Illustrated London News, I prepared a cut of this engine, and it will be found in No. 499 of that paper, about a third the size of the original. Beside this first idea of Watt's of oscillating the cylinder, were exhibited a pair of oscillating cylinder engines by J. Penn, of Greenwich, of extreme

Fig. 5.

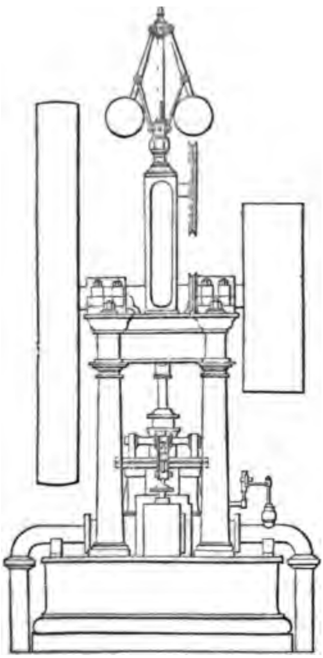
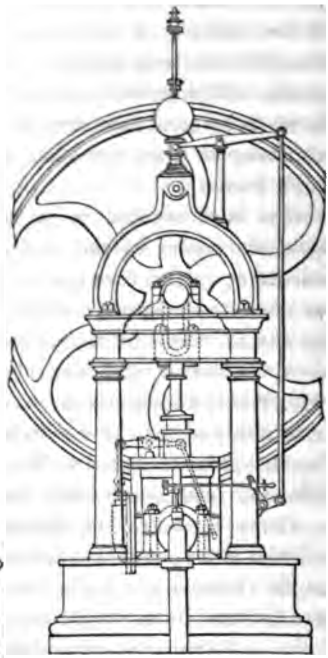


Fig. 6.



CROSSKILL'S FIXED ENGINE.

beauty, and of the most perfect workmanship that could be produced. On comparing the model of 1763, and the magnificent engines of 1852, one cannot but be struck with the [illegible] that, in the model the idea was complete; it required

but to be carried out as Mr. Penn could do it. An immense variety of the oscillating cylinder-engines have been constructed; sometimes it is placed horizontal with one trunnion, at others it is placed overhead and the crank underneath. In this manner it is called a pendulous engine. Another arrangement, and one I consider well adapted to agricultural purposes, has been manufactured by W. Evans, of Wardour Street. In this case the steam is inducted and discharged through transverse hollow trunnions, placed at the bottom of the cylinder, of a simple and scientific construction, upon which the cylinder moves. Doubtless the oscillating engine is the simplest form upon which a steam-engine can be constructed, and fixed agricultural engines are usually made on that plan; but there is one point upon which some difficulty exists, that is, the keeping the packing at the trunnions always in order; this requires considerable care and attention, which it is difficult to extract from ordinary agricultural labourers. Figs. 5 and 6 represent one of the best forms in which this engine is made for agricultural purposes; it is by Mr. Crosskill of Beverley in Yorkshire; it is simple in design, exceedingly strong, cheap in price, and in setting up requires only a flag-stone or two wooden sleepers.

In every respect this is to be recommended as an efficient farm-engine; it occupies but a small space, and is, therefore, well adapted for the colonies.

Trunk-engines.—The object of adopting the contrivance called a trunk, is to get the direct action of the oscillating engine without the inconvenience of vibrating the cylinder, and this is effected in the following manner:

In the centre of the piston is placed an iron tube or trunk, and in the cylinder cover is an aperture through which it passes, being kept steam-tight in the same manner as the ordinary piston-rod. One end of this tube is connected with the piston, and the other end is open. No piston-rod is required to this engine, as one end of the

connecting-rod is fixed to the piston itself, and the other end to the crank.

It will be easily understood now, that the deviation of the connecting-rod from a line parallel to the sides of the cylinder, will be permitted within the trunk or tube which works in and out of the cylinder as the piston rises and descends; the trunk, in fact, may be considered as a hollow piston-rod of sufficient diameter to allow of the swaying the connecting-rod within it equal to the throw of the crank.

Messrs. Penn, of Greenwich, are the introducers of this engine for marine purposes, to which it is specially adapted; and Messrs. Ransomes have adapted it for a small fixed engine for agricultural purposes, as well as to their portable engine.

It is certain that the trunk simplifies the action of the engine to a great extent, and, but for one defect, seems to me to be an almost perfect engine. This defect is the constant exposure of a large surface, like the trunk, to the external atmosphere to be cooled down at every stroke of the engine, for the atmosphere is not only in contact with the outside of the trunk each time it is drawn from the cylinder, but is always cooling down the inside surface of the tube which, at the bottom of the stroke is, of course, the whole length of the cylinder. The steam must be badly situated here, being only an annular ring cooled down from the outside of the cylinder, and the inside of the trunk; but Messrs. Ransomes' have tried these engines, and in practice it may be that these causes do not produce such appreciable effects as might be anticipated. An excellent specimen of this engine was exhibited by them at the Great Exhibition, and was employed in driving Mr. Whitworth's beautiful collection of machine tools. It is intended for the use of farmers and millers, and is thus described by the makers:—"All the parts are easy of access,

and afford every facility for adjustment and repairs. It is entirely supported by its own cast-iron frame, which is strong and neat, and does not require any attachment to the walls of the building in which it is placed; it can be either erected on a small brick-work foundation, or be placed on two wooden sleepers. It is well adapted for driving fixed thrashing machinery, either on a stage or ground floor, as the strap can be easily taken from the large pulley on the crank-shaft, to the small one on the drum-spindle of a thrashing machine, which may have been previously driven by horse-power. The engine has a wrought-iron crank shaft and connecting-rod; the slide valve is brass and on the best principle, and not liable to be put out of order, and the supply of water to the boiler is very easily regulated; there is a governor of the best construction, and an improved valve for stopping the engine without interfering with the throttle-valve.

Rotatory Engines.—It has been the aim of nearly all the constructors and improvers of the steam-engine, to construct one in which the force of the steam exerts itself continually in producing direct motion round an axis, so getting rid of all the cumbrous parallel motions, beams, connecting rods, &c. Engines acting in this manner are called rotatory. An enormous number of patents have at various times been taken out for them, but as yet there are not any sufficiently perfect in their action as to be available for agricultural purposes, nor is the loss of power from the employment of cranks and the other members of reciprocating engines nearly so great as to render it necessary for the farmer to run any risks by adapting any of the present rotatory engines. Mr. Scott Russell, in his treatise on the steam-engine, observes, "that such an elementary machine, if constructed, could give forth any more of that power than is now rendered effective by the common steam-engine in every day use, is a fallacy, arising in ignorance and ending

in disappointment." Rotatory engines have been brought to considerable perfection by Mr. Beale, Lord Dundonald, Elijah Galloway, and many others; but the one that seems most likely to realise the anticipations of its inventors is called a disc-engine, and acts in a manner quite distinct from the usual plans, attempted much in the manner the upper arm of a man works from the shoulder joint.

Those who are desirous of further information upon this subject, will find the disc and many other rotatory engines fully described and ably discussed in Mr. Ritchie's work called the Farm Engineer.

CHAPTER II.

PORTABLE STEAM-ENGINES.

The manufacturers of agricultural steam-engines have spared neither pains nor expense in endeavouring to produce a perfect portable engine. At the Great Exhibition in Hyde Park, there was quite an array of them; nearly every engineer of eminence had produced one constructed upon the most approved and tried principles, and all were so good, though differing considerably from one another in design, that it is a most difficult matter to decide which is actually the best, for, although one may have an advantage in some particular point, yet upon inquiry it will be generally found that it has been obtained at the sacrifice of some other, which its maker considered too important to be neglected. We need not, therefore, attempt to make comparisons where all are so good, but will give a short description of some of those which upon trial were found to answer thoroughly well, and received the commendations of the judges whose business it was to decide upon their respective merits.

Messrs. Garrett's Engine.—This eminent firm always make a great display of implements of every description, sparing neither pains nor expense to enable them to occupy the first place in the continually renewed struggles for pre-eminence as agricultural machinists; and it but rarely happens that they are not the recipients of some of the prizes awarded for inventions, improvements, cheapness, or superior workmanship. Their portable engine, as may be expected, is one of the best constructed, having every modification or addition applied immediately its advantage was apparent. Figs. 7, 8, and 9 represent the fore and after end and side elevations of this engine.

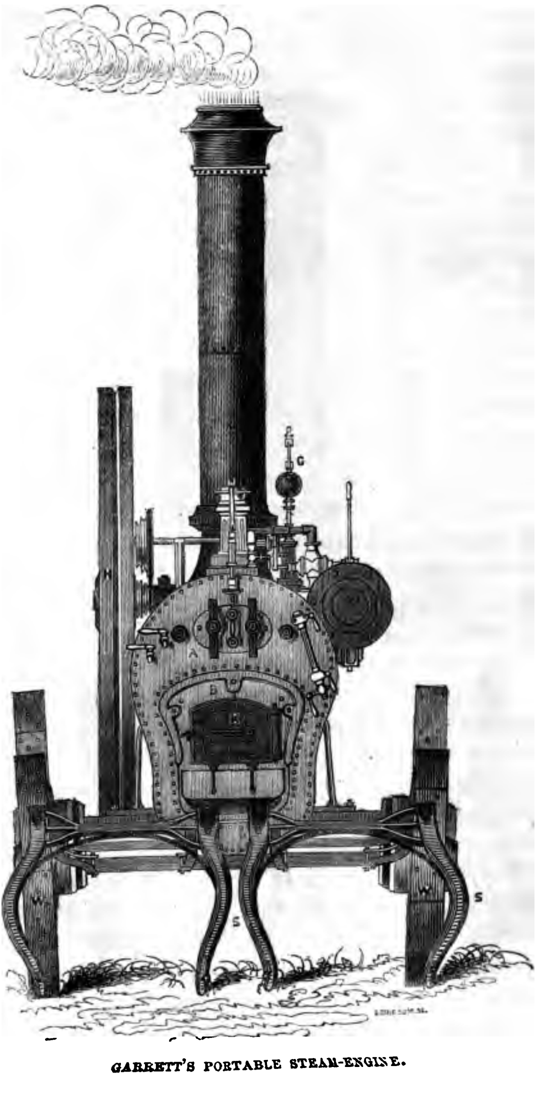
It is fitted with governor, hair-belt jacket, steam and water gauges, and other necessary appendages, mounted on four strong carriage-wheels, with shafts, and may be easily transported from place to place by two horses.

Reference to Plates.

- A A A An improved tubular boiler with oval fire grate.
- B B Fire-box of boiler.
- C C Cylinder of engine.
- D Improved guide to piston-rod, capable of being adjusted.
- E Eccentric rod for working the slide.
- F Connecting rod.
- G The governor, for regulating the speed.
- H H H The fly-wheel.
- I I I Cold water tank, to which is attached the pump for supplying the boiler.
- W W W Travelling wheels.
- S S S Shafts for two horses abreast.
- V The safety-valve, with Salter's improved balance.

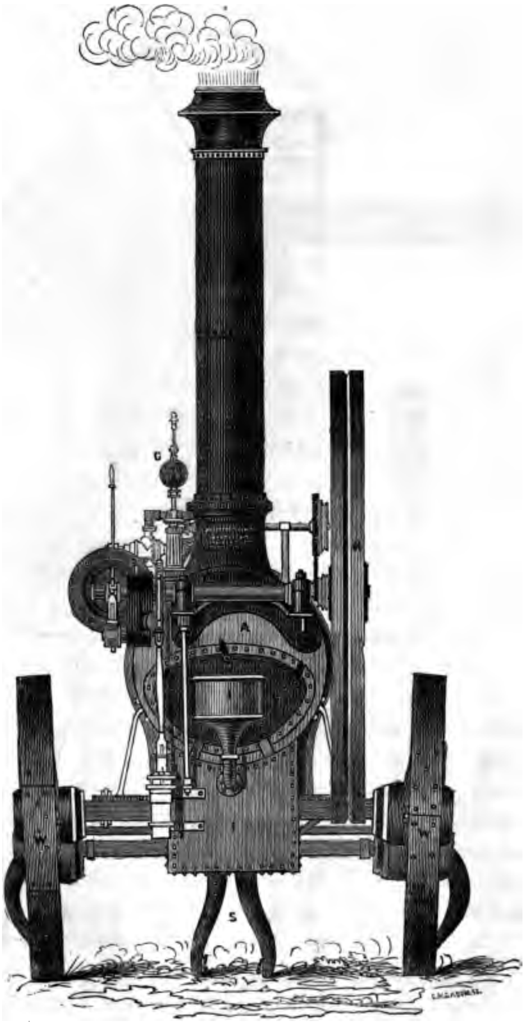
Since these cuts were prepared, this engine has been considerably lightened, and now only one pair of shafts is used instead of the arrangement shown in the cuts.

Fig. 7.—Fore-end èlevation.



GARRETT'S PORTABLE STEAM-ENGINE.

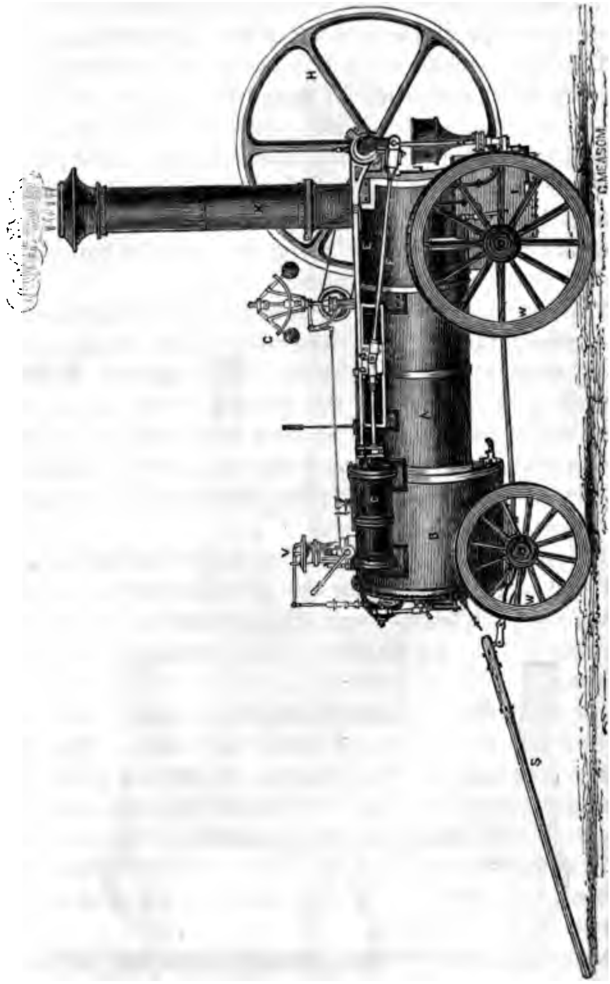
Fig. 8.—After-end elevation.



GARRETT'S PORTABLE STEAM-ENGINE.

C 2

Fig. 9.—Side elevation.



GARRETT'S PORTABLE STEAM-ENGINE.

Messrs. Hornsby's Engine.—This firm has brought the ricultural portable engine to the highest point of perfection workmanship, and in economy of fuel in producing steam. The chief peculiarity in this engine is the placing the linder and pipes connected therewith inside the boiler, or eam chamber, so effectually protecting them from the nosphere at all times. This improvement no doubt effects immense saving of fuel, as it does away with all condensa-n in the cylinder; and the less fuel is consumed, the less ar and tear there will be in the tubes and fire-box, which e the most hard-wearing parts.

This engine is exceedingly neat and compact in appearance. he cylinder (as we have before remarked) is placed in the team chamber over the furnace, the piston-rod working hrough a stuffing-box in the fore-side of it; and on the uter end of the piston-rod is a short cross head which works n two guides, which are neatly supported at the outer end y a ring, the lower part of which is screwed to the top of he barrel of the boiler.

The connecting-rod is attached to the head of the piston-od and cross-head, and, as the piston-rod passes in and ut of the cylinder, the connecting-rod has room to play in the ring in a manner similar to what it would in a trunk-engine.

The crank-shaft is supported on two plummer blocks one on each side of the boiler, a convenient distance aft of the chimney or funnel. The plummer blocks are placed on carriages formed of three short fluted Doric columns, the abacus of each being the lower portion of the plummer block: the whole is placed upon a step projecting from the boiler. It is very handsome in appearance, and quite secure and steady when working.

Above the guides for the piston-rod cross-head is placed an exceedingly well contrived governor, with an additional security for the heavy balls when the engine is travelling—

two semispherical cups being placed so as to receive the balls and keep them at rest, as their weight is apt to injure their bearings by jolting on rough roads.

The engine is fitted with metallic piston, steam-cocks, gauge-cocks, safety-valves, and all other requisites for ensuring correct working and safety.

Prizes have been awarded to the Messrs. Hornsby at the Exeter and York meetings of the Royal Agricultural Society, and the great Prize Medal at the Exhibition of all Nations, as well as by a number of local societies. At the meeting of the Royal Agricultural Society at York, the judges say, "they awarded the prize to this engine because it was stronger, steadier, better fitted, got up the steam and worked with less fuel than any other engine exhibited. It worked in every way as the exhibitor described it. It had a good boiler, to generate the steam, plenty of cylinder room to give it power, sufficient strength in all its parts to keep it steady, and an excellent governor to regulate its motion."

A more flattering report never was made nor better deserved. This engine is the result of repeated improvements and careful study of the peculiarities of engines required for agricultural purposes. Though highly scientific in its arrangement, it is nevertheless exceedingly simple; and the charge I hear repeatedly made against it, that it is difficult and expensive to repair (in consequence of the cylinder, &c., being enclosed), I am assured by Mr. Hornsby is utterly without reason: they undertake to take to pieces and reconstruct their engine in the same time that any other can be so treated. Nor do I see any difficulties arise from the situation of the cylinder, there being a manhole directly over it.

At the trial of steam-engines which took place under the direction of the executive committee at the Great Exhibition, the Messrs. Hornsby's engine, competing with others

manufactured by various makers from all parts of England, beat them all in amount of duty, the consumption of fuel being only 6¾lb. of coal per horse power per hour; or 3 cwt. 2 qrs. 13 lb. of coal per day for a six-horse engine.

At another trial (the power in both cases being proved with a dynamometer), at the North Lincolnshire Agricultural Society's meeting, held at Caistor, July, 1851, the first prize of 20*l.* was awarded, the result being reported thus:—

Their engine was of seven-horse nominal power, and consumed 36lb. of coal, on getting up the steam 37lb. per hour, being 5·28lb. per hour per horse, and 3 cwt. 1 qr. 6lb. per day of ten hours, when working up to their nominal power the whole time.

At another trial at the Yorkshire Agricultural Meeting, held at Bridlington, August, 1851, the prize was again awarded to this engine, the results being thus with four engines, from the hands of first-rate makers, Messrs. Hornsby's being No. 1:—

No. of engine.	Nominal horse power.	Coals used in getting-up the steam.	lb. of coal burnt per hour.	lb. of coals burnt per horse-power per hour.	Coals used per day of 10 hours, when working up to their nominal horse-powers.		
		lb.	lb.	lb.	cwt.	qrs.	lb.
1	7	40	51½	7.35	4	2	11
2	7	41	59½	8.50	5	1	7
3	6	48	64¼	10.70	5	2	26½
4	6	60¾	96¾	16.12	8	2	15½

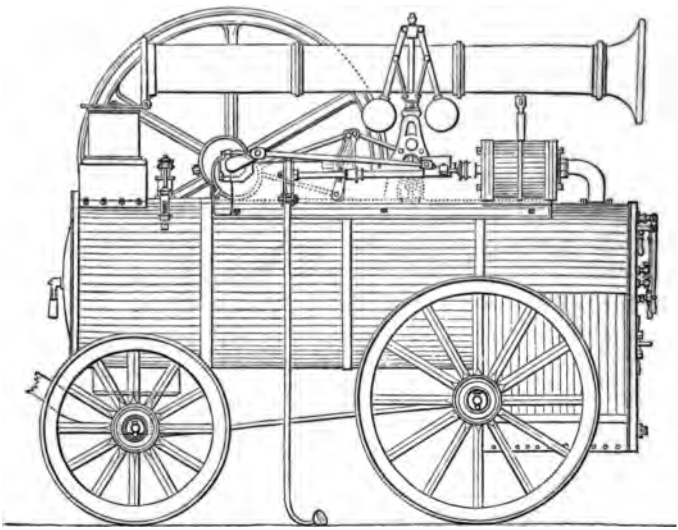
In this trial an inferior coal was used, which accounts for the increased consumption in doing the same amount of work.

The engines of this firm have now stood the test of years, and I most confidently recommend them as being, if not superior, at least equal to anything of the kind manufactured by any one.

Portable Steam-Engine, constructed by Messrs. Barrett, Exall, and Andrewes, of the Katesgrove Iron-works, Reading.

Figs. 10, 11, and 12, represent the side and end elevation of this engine, which is in every respect a most efficient one. Messrs. Barrett's ample stock of machine tools, &c., enable them to turn out everything of first-rate workman-

Fig. 10.—Side elevation.



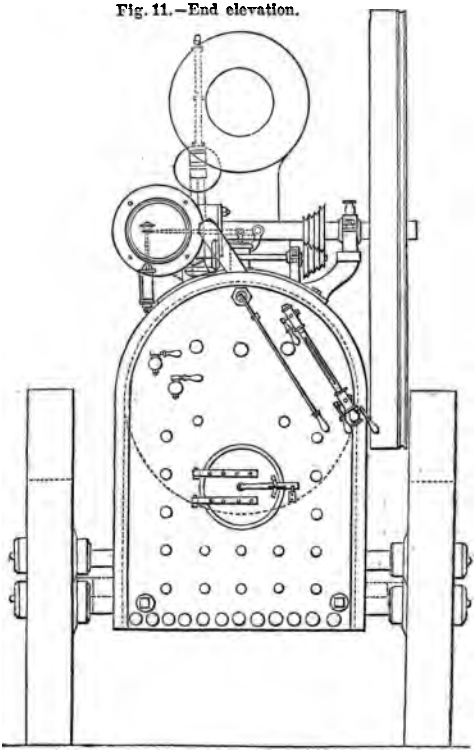
BARRETT, EXALL, AND ANDREWES'S PORTABLE STEAM-ENGINE.

ship, of which their portable steam-engine is a good example. It is constructed in the ordinary manner, with tubular boiler, &c., and the engravings will make it much more clearly understood than any written description. There is one particular point, however, that should be specially observed, and that is, the admirable manner in which the engine is arranged and secured to the boiler. Fig. 12 will show this more clearly. It consists in the engine being complete on a metal frame, independently of its attachment

to the boiler, which renders its removal easy, at any time it may be necessary, without affecting the boiler.

The average consumption (but of course varying with the

Fig. 11.—End elevation.

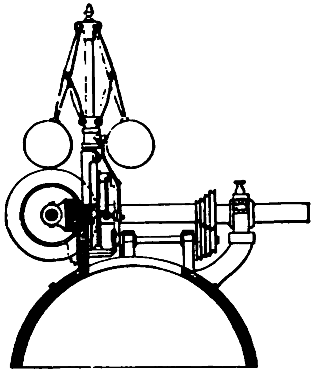


BARRETT, EXALL, AND ANDREWES'S PORTABLE STEAM-ENGINE.

quality of the coal, coke, wood, &c., employed) is found to be about 7lb. per horse-power per hour. The simple arrangement of the parts, and all being exposed to the eye, renders this engine well adapted for agricultural purposes—as a smart agricultural labourer will, with a week's instruction, be better qualified to drive it than

where the engine is out of sight or more complicated in construction.

Fig. 12.—Cross section.



CLAYTON, SHUTTLEWORTH, AND CO.'S ENGINES.

—These makers are justly celebrated for the manufacture of portable engines; they are exceedingly simple, of excellent workmanship, moderate in cost, and consume a very small quantity of fuel; they are well adapted for all the purposes for which steam is used as motive power—as thrashing, grinding, sawing, pumping, or any other purpose. With contractors for works of all kinds they are great favourites.

They are manufactured of various powers, from three horses to ten; in the latter case they are fitted with double cylinders; they are fitted up and equal in workmanship the best locomotives; the engine is well arranged and has an improved governor (which regulates the steam to the greatest nicety), starting-lever, safety-valves (which are acted upon by Salter's spring balance), water and gauge cocks, feed-pump and steam-whistle, all placed within reach of the driver, without his moving from his position in front of the boiler.

The annexed tabular statement will show the results of a trial with eight portable engines, carried out by the judges' direction at the Royal Agricultural Society's meeting, held

at Exeter, 1850, Messrs. Clayton & Shuttleworth's engine being No. 1.

No. of engine.	Time getting-up steam.	Nominal horse-pwr.	Coals used in getting-up steam.	Coals burnt per hour.	Coals burnt per ho.-pow. per hour.
	minutes.		lb.	lb.	lb.
1	43	7	36½	54½	7¾
2	40	4	52½	41½	9¾
3	105	4	60	112	28
4	85	6	64	83	13¾
5	39	9	42	68	7½
6	81	7	49¼	74	10½
7	90	6	44	66½	11
8	34	6	34	62	11¼

The small three-horse engine, manufactured by this firm, is admirably adapted for small occupiers, and will thrash out, clean and satisfactorily, 20 quarters of wheat per day of ten hours (the crop being of a fair average yield); one horse is sufficient to remove it from place to place when on turnpike roads, and, from its extreme lightness, it may be taken over bad roads and into situations that would not be accessible to engines of greater weight. The consumption of fuel for this engine is 3 cwt. for a day of ten hours; and it will require to be supplied with 270 gals. of water. The seven-horse engine weighs 50 cwt., and consumes, in a day of ten hours, 5 cwt. of coals and 450 gals. of water, and will thrash 35 quarters of mown wheat per day.

The nine-horse power engine weighs 75 cwt., and consumes 9 cwt. of coals, and 800 gals. of water in the day of ten hours.

The last engine is only adapted for farms of the largest description.

I have just seen one of the engines of this firm employed in driving some heavy iron rollers for grinding clay (as heavy a duty as could be laid upon an engine), at the Pottery Works of E. Betts, Esq., on his estate, Preston

Hall, Kent. The driver of the engine gave me a most satisfactory account of it, and seemed well pleased with it in every respect.

Messrs. Tuxford's Portable Steam-Engines.—These are considered to be good and effective engines; they are differently constructed to the generality of engines of this description, the ordinary plan being to place the cylinders and engine-work on the top, or nearly so, of the boiler, horizontally, and setting the main shaft across. In Messrs. Tuxford's engine the cylinders are placed in the smoke-box; in this they are thoroughly housed up, and being kept always hot by the draft of hot air through the tubes and by the escape of the steam, a great economy of fuel should take place, as the steam cylinders are as well off in this case as in Messrs. Hornsby's, with the advantage of being accessible at all times by merely opening the moveable plate which forms the back of the smoke-box. The cylinders are set in an upright position, sometimes fixed, and at others they are made to oscillate; there are also peculiarities in the arrangement of the tubes. The fuel consumed is about 4 cwt. per day.

Messrs. Ransomes' Portable Steam-Engine is equal in workmanship and effectiveness to any made in England, the object of this firm being to make an engine that shall do the work of agriculturists in a satisfactory manner through a long series of years, instead of making an engine especially with a view to competition at an agricultural show, the results of which must not always be taken as the sole guide in the choice of an engine. The cylinder and the machinery are placed on the top of the boiler; the engine is on the principle we have before alluded to as the trunk engine, the simplest form of engine that can be made; it is fitted with governor, regulator valve, and an efficient feed-pump. The crank-shaft and connecting-rod are of wrought-iron, and the slide-valve is of brass, and of the most improved construction. The steam and escape pipes are of copper, and consequently

not liable to injure the slide-valve and metallic packing of the piston by any scales caused by corrosion of the metal coming off the pipes and being carried by the steam into the working parts of the engines, as is frequently the case in common engines fitted with wrought-iron gas tubes (instead of copper) for steam-pipes. The boiler is made on the same principle as the locomotive boilers, and will work up to 80 lb. pressure on the square inch, should there be any necessity for it. A wrought-iron ash-pan is placed under the fire-box containing water; all hot cinders are immediately extinguished as soon as they fall, thus ensuring the greatest possible safety in working.

Between the engine frame and the axles of the wheels are interposed springs for preserving the machinery from injurious shocks while passing over rough roads. The five-horse engine will thrash, with ease, 40 quarters of wheat (of average yield) per day.

In the Report of the Royal Agricultural Society's meeting at Bristol, 1842, I find that Messrs. Ransomes exhibited a portable disc-engine (tried at Liverpool), but then set upon a carriage with four, instead of two wheels, and having a platform of sufficient dimensions for the conveyance of a thrashing machine from farm to farm. A further alteration had also been effected by applying the power of the engine to give locomotion to the carriage instead of using horses; the engine travelled along a road at the rate of from four to six miles per hour, and was guided and manœuvred so as to fix it in any particular spot with much ease; it turned also in a very small compass; the engine proved itself sufficiently powerful to drive, at full speed, a three-horse thrashing machine. The judges awarded a prize of 30*l*., but considered it questionable whether the substitution of steam for horses, as the force employed to move portable agricultural engines from place to place, would be found either more convenient or economical; they, however, highly

commended the simplicity and effectiveness of the machinery applied by Messrs. Ransomes to accomplish the purpose. This was in every way a most interesting experiment; but, as it is not now in use, I presume the makers did not find the disc-engine adapted to their purpose.

CHAPTER III.

STEAM-BOILERS.

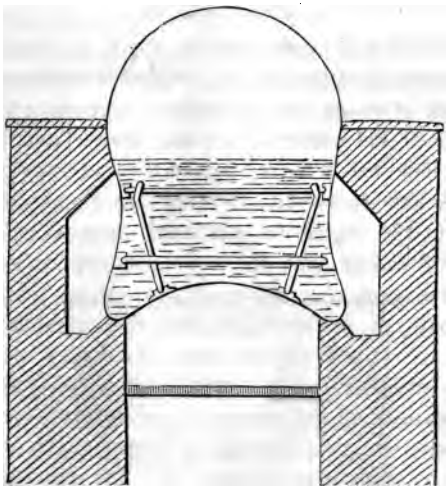
THAT those who employ or are about to employ steam-engines should possess some knowledge of the boilers for the generation of steam to supply these engines, is of the first importance. Farmers will readily understand this when they consider that it is the boilers that will more resemble the horse (whose power, &c. they are about to dispense with) than the engine, for it is this boiler that will consume the coal instead of oats, and whose goodness or badness will render the application of steam power more economical or the reverse; it is the boiler that will require the more special care of its superintendent, and which will soonest show the effects of bad treatment; and it is this same boiler that constitutes all the danger of using steam power, for if an improper one, or a bad one, its owner may be informed of that fact by some terrible explosion. The importance, then, of all those persons using steam, acquiring as much knowledge as they can of the best forms, construction, and most judicious management of steam-boilers, will not for a moment be disputed: we will therefore devote as much space as the limited size of this book will permit, to point out what are the chief points to be attended to in the choice and management of this important machine, and for further information the reader is advised to seek it in Mr. Armstrong's interesting

and valuable little work (one of this series), where he will find the whole matter treated of at considerable length, but in so simple and clear a manner that any workman of ordinary intelligence may understand it.

Steam-boilers, like the engines, are made of an infinite variety of shapes, but such as are adapted for the generation of steam for agricultural engines may be divided into the following classes :—

Low-pressure waggon-boilers, Cornish boilers, boilers with large tubes or flues, and fire-box boilers.

Fig. 13.



SECTION OF WAGGON-BOILER.

Fig. 15 is the vertical section of a waggon-boiler, showing the arrangements for heating and supplying water, with the apparatus called the safety-valve for preventing explosions. Fig. 14 is the transverse section of a boiler of the same kind. This description of boiler is the one most commonly used in factories and mills, where the motive power is a condensing engine. A boiler of this kind 20 feet long, 5 feet wide, and 6 feet 8 inches deep, will supply steam to an engine of

20-horse power, with a very moderate consumption of fuel. They are often made of the same depth and width, but longer or shorter, and each foot is considered as equal to 1-horse power. This description of boiler is always set with what is called a wheel-draft, that is, the current of flame and smoke after passing under the boiler bottom is made to rise up at the back, whence, returning along one side by a brick flue to the front, it crosses the front end, and then passes along the other side to the back, where it goes into

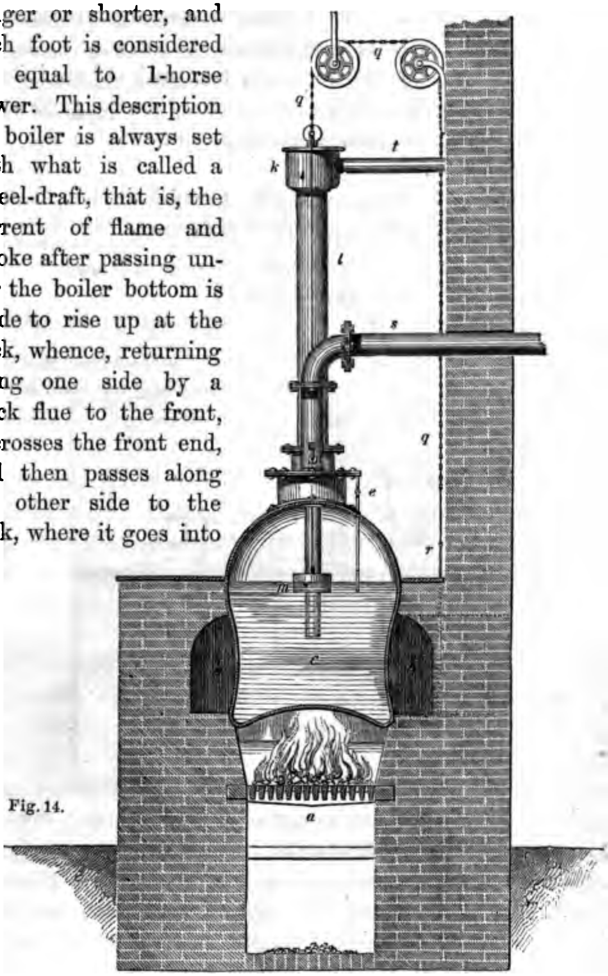
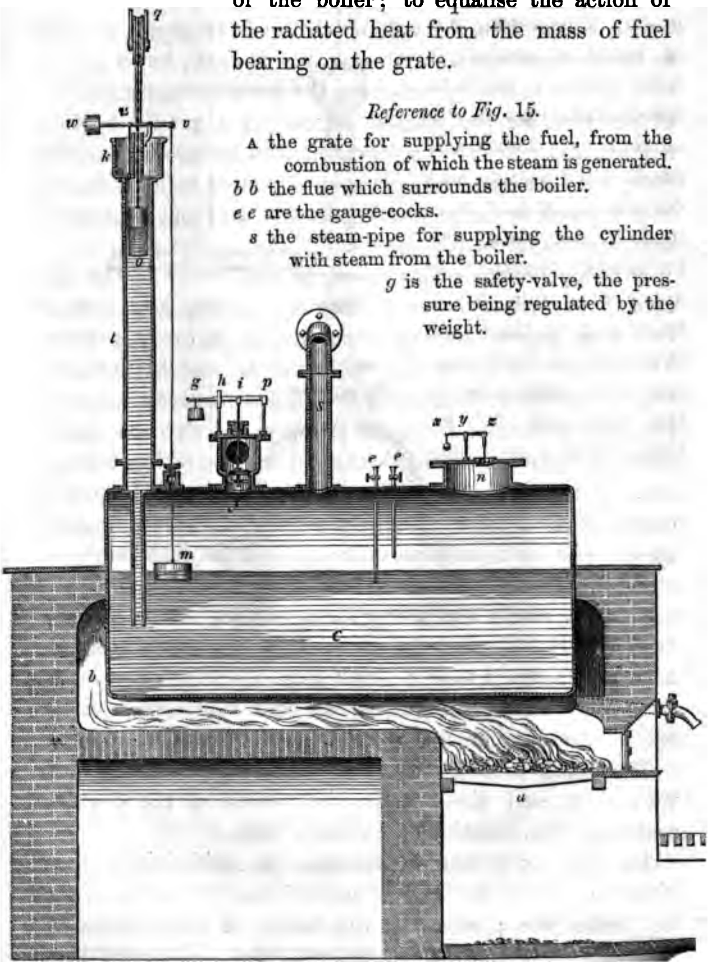


Fig. 14.

the main flue, which conducts it to the chimney. The upper part of the boiler is a semi-cylinder. The lower part

is made with concave sides outwards, 5 or 6 inches on each side, for the purpose of obtaining greater strength for resisting internal pressure. The bottom is arched upwards 10 inches, or 2 inches to each foot of the width of the boiler; to equalise the action of the radiated heat from the mass of fuel bearing on the grate.

Fig. 15.



Reference to Fig. 15.

A the grate for supplying the fuel, from the combustion of which the steam is generated.
b b the flue which surrounds the boiler.
e e are the gauge-cocks.
s the steam-pipe for supplying the cylinder with steam from the boiler.
g is the safety-valve, the pressure being regulated by the weight.

This description of boiler is well adapted for agricultural purposes, when low-pressure steam is used, as all descriptions of fuel may be burnt under it.

Flued Boilers are such as have one or more flues or tubes through them. In these the furnace is placed within the boiler, in the tube, through which the flame passes at once to the chimney shaft, if only one tube is used; but a variety of plans are in use for returning the flame through a number of passages, for the purpose of getting a greater heating surface, and extracting a larger amount of caloric from the fuel; but for agricultural purposes a circular boiler with one tube through is the one most generally used and considered best adapted for such purposes.

Fire-box Boilers.—This description of boiler is the one applied to various kinds of portable engines now coming into such general use by agriculturists in every quarter. The inventor of it was the celebrated George Stephenson, and it was first applied to the Rocket Locomotive Engine on the Manchester and Liverpool Railway. It at once superseded all the other descriptions of locomotive boilers then in use. It was examined and its effects witnessed by hundreds of engineers at the opening of the railway, and pronounced by all to be the most important improvement that had been made, and thirty years of trial has proved the fact, for it has not had a single competitor deserving the name; and the more closely the principles involved in that great invention have been adhered to since their great discoverer first made them known, the more perfect has been the locomotive for efficiency and economy combined.

The great principle of this boiler is quick combustion with short and direct draft, the reverse of the Cornish system of slow combustion and long flues.

The fire-box tubular boilers may be divided into three divisions. First, the fire-box in which the combustion of the fuel takes place; secondly, the barrel or tube boiler, in

which are placed the tubes leading the heated air from the fire-box; and thirdly, the smoke or flue box, where the tubes end, and the steam is discharged from the cylinders into the funnel or chimney above, and an intense draft thereby caused through the tubes. Mr. Armstrong considers that increasing the number of these tubes, and the diameter of the boiler, is much preferable to lengthening the tubes and boiler, as I observe some manufacturers of portable farm engines are now doing in imitation of the long boiler railway locomotive. If this is done to the extent I have heard it proposed lately by an eminent manufacturer, his patrons will, I am sure, find them to be anything but portable engines.

Whatever description of boiler is used by the agriculturist should be of as simple a form as possible, one that can be constructed in a sound and perfect manner, that can be kept clean easily, will cost as little money as possible, and that he may rely upon being perfectly safe from accidents.

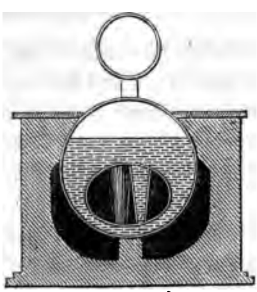
For simplicity, it happens that the best boilers are the most so; for those extraordinary forms of boilers for which patents are so continually being taken out, the farmer should have nothing to do with. The object of these is usually to extract a greater amount of caloric from the fuel. But hear what Mr. Armstrong says of them: "One of the prevalent sources of error to scientific not less than to practical men, is the apparent paradoxical fact that whatever length a boiler is made, the heated air or smoke which escapes is still capable of boiling water in a separate vessel placed in the flue leading to the chimney. This naturally induces a suspicion, that in our ordinary methods of setting boilers we only obtain a small portion of the heat derivable from the fuel."

Hence our patent offices are filled with the thousand-and-one schemes, with their various and endless winding and zigzag flues, of the numerous inventors of boilers, many of whom appear to me to have quite a mania for running after

and using up the whole of the heat, with a determination far exceeding that of the perpetual motion seekers, and with quite as little chance of success. The fact stated, however, is no way surprising: although steam may thus be raised in a close vessel, even to a much greater pressure and temperature than that in a boiler, from which the waste heat has escaped, it certainly must be allowed that steam so obtained, if returned into the boiler at a workable pressure, is *so much* clear gain. My argument, however, only is, that it is *not much*, and calculated commercially it is worth less than nothing, that is, taking time into account; for, according to what is elsewhere stated, we find the steam obtainable in that way to be produced at so slow a rate, that its value is less than a very small per-centage on the capital employed to obtain it.

Galloway's Patent Double Furnace Tubular Boiler.— This is a recent improvement in the construction of steam-boilers, and has given the greatest satisfaction. They are a combination of tubular and flue construction: it is the strongest form of boiler, for its dimensions, that has been brought into use, and is the most economic, for its weight, as a generator of steam. Figs. 16, 17, and 18 represent longitudinal and transverse sections of this boiler, showing the mode in which the main flue is supported and strengthened by a series of short vertical tubes, which are made slightly conical, or about two inches wider at the top than the bottom, and amongst which the flame is allowed to play in its passage through the flue; the tubes being plazed zigzag, which gives great facility for this purpose. This arrangement of short water-tubes, to cause them to act as stays of the

Fig. 16.



strongest possible form, and in the best position for resisting any collapse of the fire-flue, is the valuable feature in Messrs. Galloways' invention as regards safety.

In respect to the absorption of heat from the flames, the

Fig. 17.

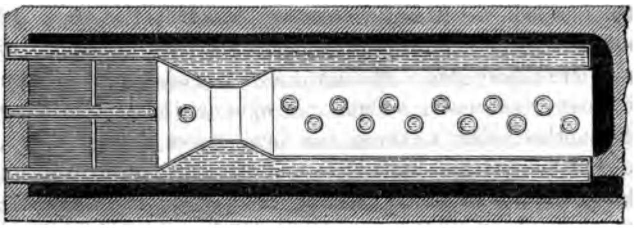
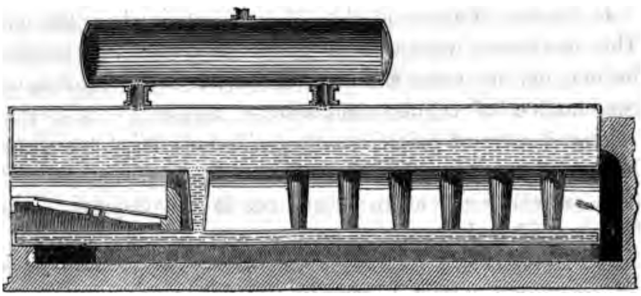


Fig. 18.



disposition of these tubes is also remarkably favourable; for, avoiding the difficulty of causing the flame to make its way through a crowded box full of comparatively small tubes, on the one hand, the tendency of the flame to divide itself into two currents, which a single row of tubes sheltering each would promote, is also prevented; on the other, this arrangement also assists in causing the flame to wrap and envelope the tubes so as to render a greater proportion of their surface effective. Hence this kind of boiler is greatly distinguished for its great economy with flaming fuel, which

is an important point, as that is the most likely to be used in heating boilers for agricultural purposes; for it should be borne in mind that different characteristics are required in a boiler for a non-flaming fuel. The boilers fitted to the agricultural portable engines, containing a number of small tubes, are certainly not so well adapted for flaming as non-flaming fuel, for it is a well known fact that the flame will not enter far into narrow tubes. Mr. Armstrong states that Mr. George Stephenson, the inventor of this description of boiler, expressed to him his opinion that the tubular locomotive boiler, so far as the small tubes are concerned, should be considered merely as an apparatus for *heating with hot air*, and not at all adapted for the use of Newcastle coal; the only object to be obtained in passing the products of combustion through an immense number of small tubes, was (as Mr. Stephenson himself expressed it) to drain out the last dregs of the caloric after the great bulk of the steam is obtained from the action of the flame in the fire-box, on which his chief reliance was placed.

This important point is worthy of the attentive consideration of the constructors of the farmers' portable engines, as the great expense of these engines is the renewal of the tubes and keeping them in repair.

Mr. Galloway's improved boilers may be seen at work at the Gutta Percha Works in the City-road, where they have been found to answer most satisfactorily; they are excellent smoke-consumers, if the two furnaces are fired alternately, and a certain time allowed between each firing, proportioned to the quantity of coal laid on, as the fire from one furnace consumes the smoke of the other, without the necessity of admitting air through any other than the ordinary openings between the bars.

The construction of the boiler, and the necessary strength it should have given to it, must be left to the maker, but it would always be well if the farmer required a written

guarantee when he purchased it that it has been proved to a certain pressure without showing symptoms of any weakness; but the fact of its having been thus tested must not induce those who use it to neglect any precaution for safely working it, for the tensile strain that good wrought-iron is capable of undergoing without rupture is so enormous that it will rarely give way to pressure fairly applied, as it is in the usual manner of testing, yet sometimes they have exploded the first time they have been used after having been so tested.

It is therefore necessary to consider the circumstances under which boilers usually explode, with a view to giving the agriculturist some information as to how he may best avoid similar catastrophes.

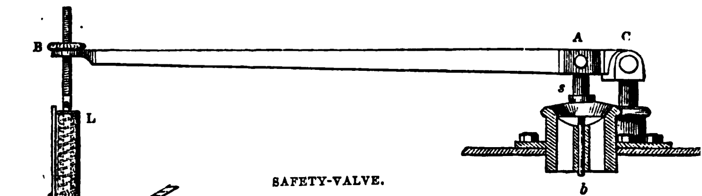
There are only two ways in which a boiler can be caused to explode, or, as it is commonly called, burst. One is by gradually increasing the pressure of the steam in the ordinary manner; it having no means of egress from the boiler it gradually increases until the plates and rivets are no longer able to bear it; a rupture of the weakest part must of course then take place. The other is when, from any cause, so sudden an increase of pressure takes place that the ordinary means provided for its liberation (as the safety-valves, &c.) are unable to act in a sufficiently rapid manner to prevent the strain the boiler is required (though only for a moment) to bear: it is to this last cause that most explosions are due, and the greatest care must be taken to prevent the circumstances arising which produce such terrible disasters. Mr. Armstrong, in the little book I have before alluded to, gives a variety of illustrations of boiler explosions under these and other circumstances, and a perusal of them, with his remarks thereon, would give a better insight into the nature of such accidents than can be acquired in any other way I know of.

The ordinary means adopted to relieve the boiler of

undue pressure is the safety-valve; this is constructed in a variety of ways, but the one most in use for high-pressure agricultural engines is shown in fig. 19, called the spring safety-valve.

The conical valve is represented in its seat; its spindle s being pressed down at A by the lever B A C; C is a fixed

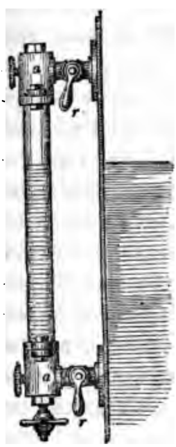
Fig. 19.



SAFETY-VALVE.

pivot, on which the lever plays; the pressure on the spindle of the valve at A is produced by a nut at B, which presses that end of the lever downwards; the nut works upon a screw, which screw is attached to a spring-balance L, the lower end of which is firmly attached to a fixed point P; the nut B may be turned so as to submit the valve to any pressure within the action of the spring-balance. As the nut is turned, the spring becomes more and more compressed. An index and scale are attached to the balance, the scale being so divided as to show the number of pounds per square inch by which the valve is pressed upon its seat.

Fig. 20.



WATER-GAUGE.

There is nothing in the principle of this valve essentially different from the common safety-valve, loaded with a weight usually applied to low pressure boilers; but the quantity of weight in this case that would have to be raised would be inconvenient.

As shortness of water is a common source of accidents, an apparatus called the water-gauge is used. Fig. 20 represents the glass water-gauge; it is composed of a glass tube with a stop-cock at each end, which communicates with the boiler, the upper one admitting steam and the lower one water; and as the pressure in the tube is the same as in the boiler, the level of the water in the tube will be the same as in the boiler. In tubular boilers, more especially, the gauge requires the constant watching of the fireman.

CHAPTER IV.

WATER-POWER.

Of all motive powers the one obtained from a fall of water is the best suited and cheapest for the agriculturist, and if it can possibly be obtained is well worth considerable trouble and first outlay. It is quite true that in this country great care has been taken of every little fall in rivers and streams, and numberless mills have been erected upon them; in fact, too many, for in times past (when land was worth less and a fall of water more) weirs were erected on streams in such a manner as to bay back the water upon the lands of the upper level to such an extent as to much injure their fertility; and in the present day there may be found very extensive districts of flat valleys kept in an unwholesome and swampy state merely to maintain the fall at some trumpery little mill; and it is not only the land immediately abutting upon the upper level of these mill waters, but if the valleys are wide and flat no fall is to be got for neighbouring proprietors to drain their lands, and thus the whole country for miles round is injured. I know many

great flat valleys in this state, and as the efficient drainage of land is now considered as necessary as putting dressings on it, some alteration in the law should take place to enable proprietors to cut drains at a low level, and by the mills, independent of their weirs. The mill-owners would object to this, as they would assert that the drainage of the land was part of their rights, and that they had a vested interest in keeping the valley a swamp. It was so in Walter Blyth's day, 1650, and seems likely to remain so.

If a low drainage level could be got to carry off subterranean water, only allowing the flood waters to go by their natural channels, water-mills might be erected in many situations where they cannot be now, and the drainage-water of the land made available as a motive power for the homestead. This has been done in several cases, and with capital results. In Mr. Williams's pamphlet on land-drainage and irrigation is a most interesting account of a water motive power procured from land drainage, at Teddesley Hay, an estate, belonging to Lord Hatherton, in Staffordshire, from which we quote the following particulars:—"The extent of land which did not require draining was comparatively small, and the whole, which consisted generally of light soil, rather inclined to peat; the subsoil being chiefly clay, has since been subjected to a regular course of thorough draining, and the water collected into two main channels, by which it is first conveyed to an extensive reservoir, which has been constructed for its reception, and from which the water flows underground for a distance of nearly half a mile, in a culvert 15 inches in diameter, to the farm buildings, where it is discharged upon an overshot wheel, and thus furnishes mill power for the various purposes connected with the estate.

"The wheel originally used was constructed of timber, and was 30 feet in diameter; from the want of sufficient natural fall in the surface of the land, between the reservoir

and the farm, no little ingenuity and contrivance were required in the arrangement of the details for using the water in the most efficient manner, and for afterwards getting rid of it. Much talent has been displayed in overcoming these difficulties, which has been done in a way which proves how completely this system of converting the water obtained from the drainage of the land, to the purpose of motive power, is applicable to the great majority of estates of any magnitude in the kingdom.

"The original timber mill-wheel has recently been replaced by one built of wrought-iron, of 38 feet in diameter, which is a model of lightness, combined with strength. This wheel is let into a chase cut into the red sand-stone rock, which here underlies the surface to the depth of its entire height of 38 feet, by which means the upper part of the wheel is brought below the level of the bottom of the reservoir, and a sufficient fall to the water, in its course to the mill, is secured. Having performed its work, the tail water is discharged from the bottom of the wheel, by a headway, which is driven through the rock, for a distance of some 500 yards, where it is discharged into a lower level of the estate, and made available for the purposes of irrigation to a large extent of upland water meadows. In the recent alterations, iron has been substituted for wood throughout the whole machinery. The extension of the radius of the wheel, would alone have enabled the mill to do more work with the same supply of water; but additional water has also been obtained, and the power of the water-wheel is now equal to twelve horses. A comparatively small portion of the water which is now derived from the drains is required for the purposes of the mill, but being soft, it is all used for the purpose of irrigation.

"The water-wheel works a thrashing-machine, cuts hay and straw, and kibbles oats and barley for a stock consisting of about 250 horses and cattle, grinds wheat and malt, and

drives circular saws, by which the sawing of all the smaller scantlings for the use of the estate is executed.

Although advocating the setting up of water-wheels, there are certain drawbacks that must not be lost sight of, such as the great cost of constructing the works for storing the water for supplying the wheel, and for carrying it clear of the mill-tail when done with, as well as its affecting the position of the steading, which should certainly not be placed in an unhealthy place for the sake of the water-wheel; but running water is in no way unhealthy, and if the ground about the steading be properly drained into the mill-tail, there is no fear of injury accruing from such source: nevertheless, it is often the case that *water power is paid too dearly for.*

Water-wheels are of three kinds, and severally called overshot, breast, undershot, and horizontal wheels, or turbines.

The overshot wheel is the most powerful form of wheel, as in this case the whole fall of the water, being something greater than the diameter of the wheel, is employed in producing the power which in some cases, where the machinery is of superior description, is as much as 75 per cent. of the actual fall of the water.

The overshot is best adapted for small streams of considerable fall; and the breast-wheel for large streams with a small fall; while the undershot, or sweepshot, as it is often called by millwrights, is chiefly used as a flood wheel, or for obtaining motive power from the ebb and flow of the tide. For a description of the manner of constructing water-wheels, turbines, &c., see Mr. Glyn's work, in this series, upon mill-work.

Water-wheels are now generally constructed of iron, and it is by far the best material; in some cases a ring of cogs is placed upon the shrouding of the wheel, and thus the speed is got up at once without the intervention of intermediate gear.

The water is supplied to the wheel from a trough or shoot, the bottom surface of which should be about 0·4 of a foot from the crown of the wheel, to allow of the water obtaining a little greater velocity than the outer edge of the wheel. On some wheels the water is admitted a little below the crown; the wheel is made in this case of a greater diameter than the depth of the fall. This plan is preferred by many old millwrights, and they assert that, in practice, it has advantages over the other plan: it is called by them bastard overshot. The width of the trough should be something less than the wheel, to prevent waste, and allow for the escape of the air from out of the buckets.

The gate, or shuttle, should be neatly constructed, and work truly and easily, which it very seldom will be found to do unless some extra pains be taken in fitting it. A winch inside the mill (working a shaft upon which are two pinions, gearing into two racks attached to the gate) is the general method employed to supply the water to the wheel.

All the works erected or made in connection with water-wheels should be done with great care, and be very accurately set out, to prevent leakage and waste; all the brickwork should be done with well-burnt bricks, set in good Roman cement, and efficient walling be placed at the junction with the banks that form the pound or head and the walls of the mill,—for unless these points be well attended to, the water will find its way to the back of the works, and in a short time make passages through to the mill-tail: when this is the case, a large outlay will soon have to be made for repairs.

In all cases, efficient hatches must be constructed for drawing off the head of water. For a description of the manner of constructing hatches, see Part III. of this work.

A properly-constructed weir should also be provided, the upper sill to be the maximum level of the head of water.

CHAPTER V.

WINDMILLS.

These machines have been used in Scotland for many years as motive power, but not with such results as to justify their being erected, unless in particular situations.

Windmills are exceedingly expensive in their first construction, and in their maintenance afterwards. They are exceedingly uncertain and irregular in their action, and the farmer finds himself entirely at the mercy of the wind as to whether he shall have his corn to market at the time he thinks fit or not. They are now fast disappearing from the face of the country, where they have been well tried, and therefore may be considered as quite inapplicable.

These objections do not apply to the use of windmills for unwatering land, as there are, no doubt, situations where these machines may be well applied, for driving scoop-wheels, &c., as is done all over Holland. For a description of these mills, and the manner of constructing them, see Part III. of this work, on field engines and implements.

CHAPTER VI.

HORSE-GEAR.

The employment of horses for working large mills is not now nearly so common as formerly, for, if four or six horses' power is required, it is much more economical to employ a steam-engine.

Very expensive horse-wheels were formerly constructed of a substantial and durable character, and fixed in an appropriate building. These are never now erected, a portable description having taken their places, and are now usually employed to drive thrashing-machines, &c.

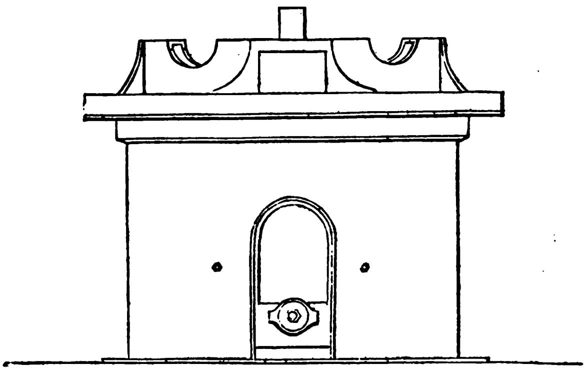
For turning edge stones, as in cyder-mills, &c., the fixed wheel may sometimes now be met with. They are of two kinds, the overhead and the underfoot wheels. The diameter of them is often made equal to the entire diameter of the horse-walk, and toothed on its outer edge. The speed is at once got up by this means, but it is exceedingly irregular in its action, and is a dead pull for the horse, there being no intermediate parts to equalise the strain by their elasticity, which is necessary to animal labour. The manner of yoking horses when employed in this way is of considerable importance, as the horse is always exerting himself in a direction tangential to the circle of his walk; the animal, therefore, should draw by a swing-tree, instead of a yoke, attached to a beam overhead. In the case of one horse hanging back and leaving the others to do his work, an arrangement has been made which effectually prevents it. It was invented by Mr. Christie, of Fifeshire, and is described in the Transactions of the Highland Agricultural Society. The principle of the arrangement is, that the ring-chain forms a figure of as many equal sides or angles as there are horses in the wheel, and that the angles shall always remain equal; by this means every horse is compelled to bear his fair share of the load.

The horse-work in common use consists of radiating bars, to which the horses are fastened, attached to an upright shaft, which works a series of wheels by which the speed is got up, and conveyed to the machine by a shaft laid horizontally and attached to another shaft by a very favourite contrivance with agricultural machinists, called a universal joint. The horses have to step or stumble over

this connecting shaft in passing round. To save their heels, some litter and a board are placed over the shaft; but the whole thing is as clumsy a concern as it is possible to find, and should never be used unless in temporary situations, as thrashing in the field, &c. If horses are employed regularly to do the work of the steading, a neat and proper machine should be constructed, with the shaft underground and an intermediate motion to carry it to the machines.

A great improvement has been made by Messrs. Barrett, Exall, & Andrewes, in the construction of the horse-work.

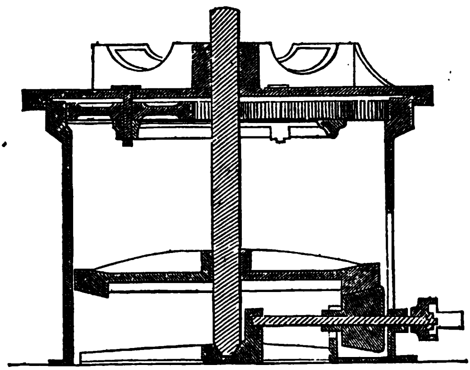
Fig. 21.—Elevation.



Figs. 21, 22, and 23 are an elevation, section, and plan of this machine. Its action is thus: on the inner edge of the cylinder are a set of cogs, which work into three loose wheels, and communicate the motion to a pinion on an upright shaft in the centre, on the bottom of this is fastened a bevel wheel working into a pinion, which communicates the power to the outside, giving 33 revolutions for each circuit of the horse, so that if the horse travels round three times in a minute, 99 revolutions are given per minute to the lay shaft.

The whole of the machinery is enclosed in a cast-iron cylinder, with a moveable cap revolving (when at work) on

Fig. 22.—Section.



its upper surface. Nothing can gain admittance into the cylinder unless purposely placed there.

Fig. 23.—Plan.

CHAPTER VII.

THE THRASHING-MACHINE.

After the anxious and arduous operations of growing and harvesting, the grain crops have been gone through, the next thing requiring the farmer's attention is preparing that grain for market and use, by separating it from the straw and chaff. The first of these processes is now effected either by the flail or the thrashing-machine. Although these two implements are now the only ones in use, it may not be out of place here to glance at the various methods adopted in ancient and more modern times for effecting these purposes.

The earliest method known or recorded for extracting the grain from the straw, is that sculptured upon the Egyptian monuments, in which the straw was laid in a circle, and oxen were driven round upon it, who, by the action of their feet rubbed out the grain.

This is the plan alluded to in the Old Testament, where it is written, "Thou shalt not muzzle the ox that treadeth out the corn."

Other passages in Scripture also allude to different plans, as in Isaiah, xxviii. 28—"Bread-corn is bruised; because he will not ever be threshing it, nor break it with the wheel of his cart, nor bruise it with his horsemen."

But there is no doubt that the flail and thrashing-floor, something similar to that in present use, was known to, and used by the Jews, as in the same chapter, 27th verse,—"For the fitches are not threshed with a threshing instrument, neither is a cart-wheel turned about upon the cummin; but the fitches are beaten out with a staff, and the cummin with a rod." The flail was also used, as well as other plans, by the Romans, and frequent mention is made of the thrashing-

floor, its situation, and manner of construction, by Columella, Varro, and other writers, and it is from that enlightened people, that the early inhabitants of these islands were first made acquainted with these and other operations connected with husbandry.

The flail continued to be the chief implement used for thrashing in England, until about the year 1732, when mention is made of a machine for thrashing, invented by Mr. Michael Menzies, which is thus described in the "Gentleman's Magazine," 1751 :—

"A gentleman at Dalkeith, Edinburgh, in Scotland, has invented a machine for thrashing grain, which in a minute gives 1320 strokes, as many as 33 men thrashing briskly. But as men rest sometimes, and the machine never stops, it will give more strokes in a day than 40 men by common supples, and with as much strength. It does not take more room than two men thrashing, but gets 6 per cent., or one peck, more in a boll, out of the straw, than in the common way. It goes while a water-mill is grinding, but may be turned by wind or horse. The inventor has a patent, and can make them of smaller sizes, to do the work of eight or ten men."

Notwithstanding this laudatory description, the machine never came into general use, and the reason given by Mr. Robert Brown, in speaking of it, is, that the flails of which it was composed were very soon destroyed from the velocity at which it was necessary to drive it; and it seems that the only benefit derived from the implement was that it caused public attention to be directed to the subject, and in the end a more perfect machine was the result.

During the next twenty years, various attempts were made to construct a thrashing-machine. One of the most prominent was invented by Mr. Michael Stirling, a farmer at Dumblane, Perthshire, described as something like a flax-dressing mill, the corn being let down into a cylinder, in

which were arms or beaters, turning upon a vertical shaft, running at a high velocity. The grain was beaten out by these arms, and passing through the floor, left the straw behind. Another, in 1772, by two gentlemen of Alnwick, Northumberland, named Ilderton and Smart. In this, the sheaves were carried round between an indented drum and a number of fluted rollers, which, pressing by means of springs against the drum, rubbed out the grain. Another, in 1785, was invented by one William Winlaw, of London. This machine is described by Mr. Ransome, in his book of the Implements of Agriculture, as being made on a principle similar to a common coffee-mill. This machine, he observes, effected another object, not described in the specification, and one which the inventor hardly contemplated—for it *ground* the corn as well as thrashed it.

In 1792 another machine was made, somewhat similar to the one originally constructed by Menzies. In this, a number of loose flails were made to act upon a grated floor, the straw being presented to the action of the flails by hand. In 1795 one Jubb, of Lewes, obtained a patent for another machine, with revolving beaters, the straw being held in its place by feeding rollers.

Not one of these machines came into general use, and they are now mere matters of history.

MEIKLE'S THRASHING-MACHINE.

During the latter part of this time, the attention of a most ingenious mechanic had been directed to the construction of a thrashing-machine. His name was Andrew Meikle, millwright, of Houston Mill, Tyningham, East Lothian. Sir Francis Kinloch, Bart., of Gilmerton, had a thrashing-machine constructed, which he sent to Meikle to try some experiments with. It however did not succeed; and Meikle, after various attempts to improve upon it, abandoned it as hopeless. He next set about constructing

another, upon a totally different plan, and, in 1786, produced the first really useful thrashing-machine; and the principle of this has been the basis upon which all other machines, up to the present time, have been constructed. The mode he adopted was that of introducing between two rollers the corn, which was then acted upon by four beaters fixed upon a revolving drum, these rollers striking as they revolved. The machine was found to answer so well, that an immediate application was made to secure the invention by patent, which was obtained after some slight opposition. In Mr. Ransome's book are copies of the original drawings accompanying the specification, and are, as he observes, exceedingly interesting, as showing how comparatively successful was this early design for the full accomplishment of the purpose intended.

Between the time of constructing the first machine and the completion of the patent, a most important improvement was made in the form of the beater, by substituting a sharp edge in place of the original flat-faced bar, by which means the grain was scutched instead of being beaten out. Mr. Ransome illustrates this difference of principle, by supposing a handful of straw, with the corn in the ear, to be held in the hand, while, with the flat side of a thin piece of wood, the ears should be struck or beaten. This is the operation of the common beater. If, instead of striking the corn with the flat side, a sharp blow be given with the thin edge, in the direction of the ear, it will strip the corn from such parts as the edge touches with less labour and with greater certainty.

The merits of Mr. Meikle's machine having been now satisfactorily proved, its fame spread abroad, and, as might be expected, it was soon imitated by other millwrights, some of whom claimed to be the inventors of it. Still it did not, for the first ten years, come much into use, nor did the inventor reap any great benefit from it. It is, however,

satisfactory to know, on the authority of Mr. Robert Brown, that a society of gentlemen, headed by Sir John Sinclair, raised a fund sufficient to render his declining years comfortable, and enable him to provide for his family.

Professor Low says, "To Andrew Meikle belongs the honour of having invented the first thrashing-machine. Changes and improvements have indeed been made in certain parts of the original machine, but in all its essential parts, and in the principle of its construction, it remains as it came from the hands of the inventor."

Thrashing-machines upon Meikle's principle are now common in Scotland, and few large farms are without one. These thrashing-machines, or thrashing-mills, as they are generally called, are regularly constructed works, permanently fixed, and are very expensive in their first cost. A few have been erected in England upon the example farms of noblemen, as at Holkham, Whitfield, and other places; but they cannot be said to be in general use. The machine used in England is simply a thrashing-machine, and is generally portable, while the Scotch machine is always fixed, and has winnowing apparatus attached: it is much clumsier in construction, and though acting upon the grain by beaters placed on a drum parallel to its axis, yet the principle of forcing the grain from the husk is quite different. In the Scotch machines, the grain being held fast between rollers is subjected to the action of the revolving beaters, and the corn scutched or beaten out, the concave or breasting having little to do with it; while in the English machines the breasting plays the most important part, the grain being rubbed out instead of being beaten out during its passage between the concave and the cylinder, which is driven at a much higher velocity in the English machines than in the Scotch. One great difference in the action of the machines is, that in the Scotch the beaters strike upwards in nearly all cases: in England it is the

reverse; the corn never is sufficiently long subjected to the action of the beaters in consequence. The feeding rollers are generally made fluted or indented longitudinally in some way, as they are when smooth very liable to clog by the straw wrapping itself round them, should it be in a damp state. They are usually about four inches in diameter, and wider than the drum, and made of cast-iron. They are worked by gear attached to part of the machine in motion, and require to have their speed regulated according to the description and condition of the material they are working with.

The cylinder is made a close drum with the beaters as projections upon it; in the English machines it is nearly always open. The diameter of the drum is generally about 3 feet, and varies in width from 2 feet 6 inches to 4 feet and even 5 feet; about 3 feet 6 inches is the ordinary dimension.

Attached to the machine for thrashing is an apparatus for shaking the straw; this is generally formed of another large close cylinder, having tines or spikes projecting from it; generally two of these shakers are attached to each machine; they revolve much slower than the thrashing-drum, and are driven with cog-gear. The whole is fitted up in one large case, and is generally placed upon an elevated stage, or upper floor of the barn, to allow of the blowing, winnowing, or cleaning machinery being arranged beneath it; there are several other contrivances for effecting different objects, such as lifting the sheaves to the feed-rollers and raising the corn, after it has been thrashed out from the husk, to the hoppers of the cleaning machine.

One of the best and most complete thrashing-machines erected is at Whitfield, and the following description I have extracted from Mr. Ransome's book (The Implements of Agriculture), where the early contrivances and the progress of the thrashing-machine are treated at great length, and

some interesting cuts inserted of the earliest attempts to construct this important machine:—

"This machine is worked by a steam-engine of six-horse power. The corn is brought from the stack upon waggons, running along a tram-road upon an inclined plane, to the doors of the building, whence, sheaf by sheaf, it is thrown by children into the buckets of an elevator, which, in its rotation, carries them to the feeding-board. This feeding-board is placed at a tangent from the drum parallel with its top; and, as in Lee's machine, and the portable machines in Suffolk and Norfolk, the feeding-rollers are dispensed with; an endless web gradually carries the unthrashed straw to the feeding mouth, from which the revolving scutchers rapidly convey it to the concave. The drum is about 18 inches diameter, formed of sheet-iron strained round a cast-iron skeleton, accurately turned. Upon this the beaters, or rather scutchers, formed of angle iron with its edges planed, are so placed as to describe an angle with the surface of the drum, pointing forward in the direction of its motion; these project about $\frac{7}{8}$ of an inch. The screen, or concave, incloses the drum to the extent of about $\frac{1}{3}$ of its circumference, and consists of four or five arched pieces of grating, 3 inches wide, joined together. It is made of cast-iron bars, having a square section placed so that every one shall present an edge to the passage of the straw, uniting (as it is not uncommon in other machines) the fluted concave of the Scotch machine with the wired grating of the English ones. The screen is supported on iron bolts, so that it approaches to within about $\frac{1}{8}$ of an inch of the edge of the scutcher. Spiral springs surround these bolts, which permit the bars of the concave to yield when too much pressure may at any time occur between them and the revolving drum. The grain is thus separated, most of it passing through the screen of the concave; but in order that no grain shall be allowed to pass away with the straw,

it is thrown upon the shaker below. This is a moveable harp or screen, and is made of spars $\frac{3}{4}$ of an inch from one another, 2 inches deep, $\frac{3}{4}$ of an inch wide, and 6 feet long; they are thirty in number, and are thus arranged over a width of 3 feet 9 inches. These spars are fixed to two pair of frames—the odd, 1, 3, 5, &c., being attached to one pair, and the even numbers, 2, 4, 6, to the other pair. These frames are supported by two iron shafts, each having two cranks projecting $3\frac{1}{2}$ inches on each side of them; the frames are attached to these cranks by arms with brasses, in which the cranks revolve; the shafts are connected together by a rod, so that they both move at the same time. In the revolution of the cranks, everything attached to them also revolves; so that each point of the arms, frames, and spars revolves about a centre belonging to itself only; at the same time, the regularity in the length of the crank, and the uniform motion of the two shafts, has the effect of keeping the frames always parallel; their position at any one point being parallel to their position at any other. The blows occasioned, as each series of spars strike the straw from beneath, effectively remove every particle of loose grain, while the shaker rapidly carries forward the straw, and at its termination deposits it in the straw-house, while the corn, sifted out by its action, falls before the blast of a fanner; and all the light grain and short straws, thrown out by the first winnowing into the light corn spout, is then taken up by another elevator, deposited again upon the feeding-board, and passed a second time through the drum, in order effectually to separate any that may remain. After passing through another winnower, the thoroughly cleaned corn is taken up by a third elevator and dropped into a hopper, through which it passes into a sack, which is placed on a weighing machine, and it is there weighed and left thoroughly fit for market."

The English thrashing-machine, as we have before observed,

is simply a machine to separate the kernels of the corn from the husks; it is therefore smaller and much cheaper; and as the large fixed machine will never make a sufficiently clean sample of wheat for market, the English farmers prefer performing all the operations of cleaning entirely separate from the thrashing process.

The original inventor of the English machine seems to have been H. P. Lee, Esq., of Maidenhead Thicket; for he first got rid of the cumbrous feeding-rollers and arranged the concave as it is now used. The English machine now in use consists of a cylinder with five or six beaters attached on arms which radiate from the centre. These beaters are variously formed by different makers; sometimes they are square bars of wood faced with iron plates; at another they are circular iron rods, or semicircular bars striking with their sharp edges, and in one class of machines they are bars with serrated or notched faces. These beaters, scutchers, or rubbers—for they combine the three operations, in their passage by the concave—force out the grain from the husks. The concave, or screen, surrounds the drum for about the third part of its circumference; it, like the beaters, is formed in a variety of ways, but generally consists of a series of ribs, between which is placed a wire grating; the front of the ribs is generally covered with a plate of cast-iron having a fluted or grooved face. The straw is fed over a feeding-board, the heads foremost into the space between the concave and the breasting, and drawn through by the revolving cylinder. The space between the concave and the drum is adjusted by means of two screws; it is usual to set the opening at the feed about an inch and a half, and decrease it to about an inch where the straw is delivered. A harp, or screen, is placed here, through which the corn falls, and the straw is removed with forks.

Machines upon this principle, with slight modifications, are now made by all the large manufacturers, and an

important addition has lately been made for shaking the straw after it leaves the cylinder; this principle is applied to the machines manufactured by Mr. Garrett, and is shown in Fig. 26. Messrs. Hornsby also construct it, and Messrs. Clayton & Shuttleworth manufacture a most efficient machine, of which they have favoured me with the following description:—

"The chief novelty in this machine is the (registered) vibrating trough, which is suspended by four links, and extends the whole length of the machine and straw-shaker, and has a reciprocating motion given to it by means of a crank. The great quantity of pulse, or colder, which drops through the bars of the straw-shaker, has long been considered very objectionable, inasmuch as it increases consider-

Fig. 24.

GARRETT'S THRASHING-MACHINE PACKED FOR TRAVELLING.

ably the amount of labour in the barn, both at the time of thrashing, and also when going through the dressing-machine.

GARRETT'S THRASHING-MACHINE AND HORSE-GEAR.

But, by means of the vibrati trough, the whole, as it dro from the thrashing-drum an straw-shaker, is caught an passed over a riddle; unde which the blast is directed, thereby effectually separating the corn, chaff, and pulse from each other, each being discharged into the places assigned for them, thus effecting a considerable saving in manual labour."

As the English farm steadings are at present generally without fixed motive power, the thrashing-machine is usually constructed in a portable form, and is made to pack up neatly with the horse work, and can so be removed from place to place. Fig. 24 represents the machine as packed for travelling, and Fig. 25 as arranged for work in the field.

Straw that has passed through a machine is, from being broken, rendered unfit for thatching and other purposes. A machine therefore has been introduced for thrashing the straw lengthways, and is called a bolting machine. I am not aware who was the first inventor of it; I believe it was

the Messrs. Garrett. I find the following notice of one introduced to the Royal Agricultural Society by Messrs. Ransomes & May, at the Derby Meeting in 1843:—

"A wheat thrashing-machine, by Messrs. Ransome, was distinguished by some novelties which deserve notice. It was driven by the horse-engine previously referred to as having the connecting shaft over head; its chief characteristics consist in an arrangement of the beaters, so that they are fed with the straw and ears in a horizontal, instead of a vertical direction, by which means the straw is delivered flat, straight, and unbroken. Thus the straw, after being thrashed, issues in a state ready for immediate tying up. The machine is also furnished with a contrivance for conveying and shaking the straw. The judges cannot but highly commend Messrs. Ransome's efforts and ingenuity in perfecting a species of thrashing-machine more particularly coveted by farmers residing near large towns, to whom the production of clean unbroken straw is frequently an object of more importance than the thrashing out the greatest possible quantity of grain in a given time."

Fig. 26 represents a section of what may be considered one of the best specimens of the English thrashing-machine, all the most recent improvements being applied to it. It is manufactured by Messrs. Garrett, of Leiston Works, near Saxmundham, Suffolk, who have devoted the greatest possible attention to the improving this important machine. The form of the beaters and the concave is peculiar; and is the result of repeated trials and experiments.

Reference to Plate.

A Drum, of improved construction, which performs the operation of thrashing.

B Concave or breastwork surrounding the drum, adjusted by the regulating irons, *b b b*.

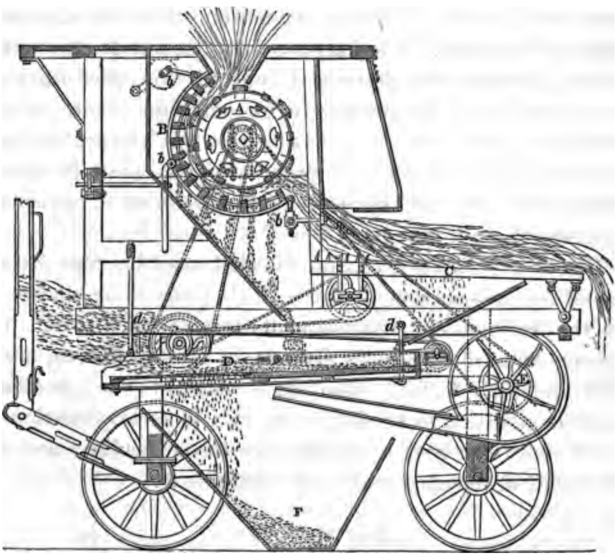
C Straw-shaker, which receives the straw from the drum of the machine, and shakes out all loose kernels that may be amongst it.

D Screen vibrating on the rods, *d d*, the corn, chaff, &c., being conducted from the concave and shaker; it is for the purpose of separating the loose ears, short straws, cavings, &c., from amongst the corn and light chaff.

E Blast fan, for winnowing the light chaff from the corn, while the corn is passing over the screen, D.

F An apartment for the corn after it has gone through the various processes above described; it is delivered free from all chaff or rubbish. If the thrashing apparatus is fixed in a building, the corn may be conducted from this receptacle to the dressing machine, *once* passing through the sieves of which will render it fit for market.

Fig. 26.—Section.



GARRETT'S IMPROVED THRASHING-MACHINE AND STRAW-SHAKER.

One of the great defects in the thrashing-machine is the difficulty of adjusting the concave or breasting to the *different widths* of opening necessary for the different

descriptions of grain to be thrashed; as it is evident that drawing the one circle from without the other will leave a space greater in the middle than at either end. The breasting is generally made in two pieces, and adjusted with screws, to accommodate itself, as nearly as possible, to the drum; but it is then in anything but a perfect state; and bad thrashing is generally the result of too much meddling with these screws, when the machine is in the hands of the ordinary farm labourer.

Messrs. Barrett, Exall, and Andrewes are the patentees of an improved thrashing-machine, in which this difficulty is got rid of in a most ingenious manner, by the introduction of a wrought-iron concave, or breasting, formed of separate bars, with grooved faces, working through slots in the side of the machine, and brought nearer to, or carried further from, the drum, by means of two circles. These work round its centre, with a continuous grooved worm cut on their faces, in which the breasting-bars move. This arrangement allows the bars to separate wider from each other, as well as more distant from the drum; and thus gives the larger corn, beans, peas, &c., a wider space to escape when thrashed.

Messrs. Hensman's improvements are thus described by them in their catalogue: (I have had no personal experience with Hensman's machines, but I know from report that they are thought very highly of by those who use them;)—

"One great feature of importance in the construction of these machines, and which makes them of the utmost value to agriculturists, is, the outer edges of the beaters, or thrashing cylinder, being of a vandyke or tooth shape, which revolve between similar notches in the concave; and is found to search the straw so perfectly, as to get out all the grain, without injuring either corn or straw more than flail-thrashing. They will also thrash with the concave, at a great distance from the drum, whereby the draught of the

horses is much diminished; in addition to which they are so arranged that the horses do not require to be driven faster than the usual ploughing pace, as over-driving is always found to distress farm horses more than the draught of the machine.

"By the use of these machines, the evils so long complained of in barley-thrashing on the old principle, are entirely dispensed with: viz., those of passing it through the machine twice, and of injuring it for malting. They are warranted to thrash barley, and all other grain, perfectly clean, at one operation; the process being more like rubbing or stripping than beating the corn. The necessary speed of the drum is procured by three motions, instead of two only, as was formerly the plan: and this alteration, with other improvements throughout, has added considerably to the ease of working, and much diminished the wear and tear of the machine."

CHAPTER VIII.

WINNOWING MACHINES.—HUMMELING MACHINES.—SMUT MACHINE.—SEED SEPARATING MACHINE.

THE WINNOWING-MACHINE.

After the grains of corn have been forced from the husks by the action of the beaters of the thrashing-machine, or the flail, it is necessary to separate them from the hulls, chaff, or caving, as it is variously called, as well as from all small seeds, little stones, dirt, and other matter, that shall take from the cleanliness of the sample. This is effected by the operation called winnowing.

In the earlier ages this was performed by merely lifting the corn and chaff in long narrow shovels, and against the

direction of the wind. The chaff, being so much lighter, was by this means, in its passage from the shovels to the ground, blown a considerable distance from the wheat, and an imperfect separation took place. An immense variety of contrivances are alluded to in Scripture, and in classic writings, as being employed to separate the chaff from the corn. Sieves are often alluded to, and fans, from which it may be presumed that an artificial draft was early obtained, as it would be exceedingly inconvenient to be waiting for a natural wind. Roman writers, however, speak of waiting for the wind; and Columella describes how the corn should be heaped, that it may not injure from lying on the floor. He also alludes to the using of fans, should no wind blow, from which I judge his fanning apparatus to be so inconvenient and ineffective, that it was only used in cases of sheer necessity. He also remarks on the danger of waiting, lest when the wind does come, it may be a storm, and blow corn and chaff away together.

Sieves were used to give the corn a second dressing, after the chaff had been removed, and to take out stones, dirt, &c. Common fans are used now in various parts of Asia, with a sieve for cleaning corn.

Mr. Ritchie describes the manner of winnowing in the western highlands of Scotland as being in a most primitive state:—"The grain is winnowed by a fan or shovel, which is made of sheepskin, stretched on a wooden hoop or circle, about two inches deep. Two sieves or riddles are also used; the one perforated with large and the other with small holes. The Highland barns are of the most simple and antique description. The barn has two doors, which, during the operation are left open; and the person who winnows stands in the middle between the two doors, lifts the grain in the fan, holds it in both hands, shakes it slightly with one hand, and the grain drops gently, while the husks are carried away by the current of wind entering at one door

and blowing out at the other. This has been until late the ordinary manner of winnowing all over England; th only difference being in the form of fan; the one in genera use in England being made of two upright supports, with a notch in the top, in which rested a horizontal shaft. Upon this shaft was placed four bars of wood parallel with it, and about fifteen inches from it: the connection being formed with wooden arms. On the outer edge of these bars is fastened a piece of cloth by one edge only. This reel or fanner is placed on the wooden supports, and turned by a winch fixed at one end, the pieces of cloth flying out from the bars, and as the machine revolves, a considerable current of air is produced. This machine will be found in many old farmeries at this day.

The first regular winnowing-machine used either in England or Scotland was introduced from Holland, by Andrew Fletcher of Saltoun.

The Dutch had no doubt previously obtained the idea from the East Indies, as a machine for driving off chaff and dust was invented and applied by the Chinese to the cleaning of rice. In Holland this machine is attached to mills for making pot or pearl barley.

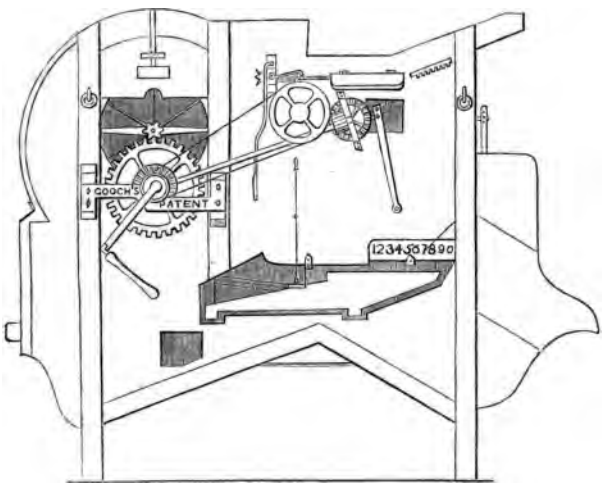
James Meikle, father to Meikle who invented the thrashing-machine, was sent to Holland by the Laird of Saltoun to learn the art of sheeling barley, in order to effect the introduction of the barley-mill.

On Meikle's return he made the first fanners ever seen in Great Britain for the Saltoun Barley Mills. Meikle was bound in his agreement with the laird not to communicate the art he had learned to any other, nor to make any profit of it after leaving the laird's service.

A large and improved form of this machine, applicable to the cleaning all sorts of grain, began to be manufactured about 1733, by Rogers, of Cavers, Roxburghshire. These machines, though greatly preferable to the old methods o

dressing by hand, were still in a rude state, and the corn required to be passed two or three times through the machine before it was a clean marketable sample. In 1768 other improvements were added, and a patent taken out by A. R. Meikle. Moodie, of Lilliesheaf, seems to have been the inventor of the first machine that would at one operation separate the grain from the chaff and lighter seeds, and completely riddle it of all sorts of refuse; Mr. Gooch, of Northampton, in the year 1800, patented a highly improved machine (upon which are based all the winnowing-machines at present in use).

Fig. 27.



GOOCH'S PATENT WINNOWING-MACHINE.

This machine, invented in 1800, gained a prize in 1841 from the Royal Agricultural Society, and his machine is at the present time considered one of the very best in use.

The principle upon which the modern improved winnowing-

rubbing it sustains from the revolving blades depending on the size of the opening through which it is allowed to escape, and which is easily regulated, a very high velocity is given to the upright shaft and the blades, to ensure their efficient action.

Messrs. Ransomes manufacture a barley-hummeler of an efficient character. It consists of a perforated iron barrel, on a wood stand, with a revolving spindle, fitted with blunt knives, which revolve at a high velocity. There is a slide at the bottom of the hopper to regulate the feed into the barrel; beneath this is another slide to regulate the passage of the barley down the spout when finished. Care is requisite not to fill the barrel too full, as it increases the labour of turning, without any corresponding advantage. A rough sample of wheat is much improved by running it through this machine.

From eight to ten quarters of barley may be run through per hour by a man and a boy. Messrs. Garrett also manufacture an excellent machine with the cylinder inclined instead of horizontal, as in Messrs. Ransome's, or upright, as in the old machines; it effectually rubs off the awns from the barley, and screens away all loose rubbish from the corn, leaving the kernels clean and the sample brighter.

THE SMUT-MACHINE.

This is a very useful machine, not costly, and consuming very little power; therefore one ought to be attached to all farmeries, where anything like a regular system of machines is erected. We all know how much the state of the sample of wheat, as regards cleanliness and soundness, affects the price it will fetch at market, and therefore how much it must be to the farmer's advantage always to send his corn, of whatever description, to market in the best possible condition.

The smut-machine is so called, because chiefly used by

millers for extracting the black specks, or powder, from wheat which has become smutted.

Smut in wheat is an exceedingly common disease of the plant; it shows itself by a black powder taking the place occupied by the farina in sound corn, within the husk; it attacks all sorts of corn, and presents a great diversity of appearance, and bears a number of popular names; it arises from two minute conimycetous fungi—the *uredo segetum*, and the *uredo fœtida*: sometimes it exists only in exceedingly small specks, and at another the whole of the shell of the grain is full of fine sooty powder.

It may easily be imagined, that wheat so affected, when ground, will be very inferior in appearance to sound wheat flour. The smut-machine is therefore employed to clear out from the wheat all the black matter that may be in it, which it does most effectively; and not only the actual smut is taken out, but all other dirt and foreign matter is removed, while the grain assumes a clean, bright, and polished appearance, which millers like, as they know it will make superior and brighter flour.

Fig. 28.

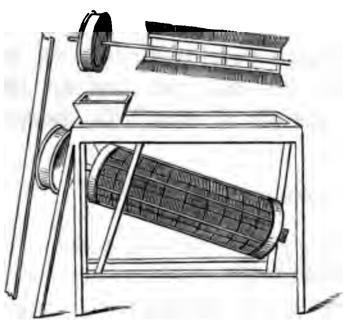


Fig. 28 represents the ordinary manner of constructing smut-machines. In a wooden case, enclosed on every side, is placed a cylinder of stout wire, and inclined downwards at a considerable angle; the cylinder is constructed in every respect similar to an ordinary dressing-machine; through the centre of the cylinder is a shaft, upon which is placed a series of arms, and lengthways of the cylinder; upon these, spars of wood, which carry strong brushes. The wheat is

admitted at the upper end, and in passing through the cylinder is forced against the wire grating, while the action of the brushes effectually forces the smut or dirt through the meshes of the wire, or any small seeds that may have escaped the winnowing-machine; the dirt remains in the box outside the cylinder, from whence it is occasionally removed; and the amount of filth that will be brushed out from the wheat after it has been made as fair a sample as possible by the fanners, will prove to any one the necessity of its always being used.

SEED-SEPARATING MACHINE.

A variety of machines for effecting this object have been devised. An excellent one was invented by W. Robinson, of Belfast, and exhibited by Messrs. Deane, Dray, & Co., at the Smithfield Club Show last year. It consists of a long wire screen, set at an angle, and composed of a variety of different-sized wire gratings: to this screen a peculiar reciprocating and shaking motion was given by means of a crank placed at its lower end; it will clean and separate rye-grass, taking away the foil-grass, black seed, and all other small seeds, by only passing once through the machine, and likewise make a perfect sample of flax-seed and corn.

CHAPTER IX.

GRINDING-MILLS.

Some machines for bruising or grinding corn must have been used in the most remote times. The first doubtless was a kind of bowl, in which the wheat was pounded as with a pestle and mortar. It is a remarkable fact that the most ancient mills of which we have any account are nearly upon

the same principle as those in common use at this day, that is, composed of circular flat stones, the bottom one fixed, the upper one revolving upon it. At first these mills were made to hold in the lap, and work with one hand, and afterwards by levers, in the manner of a capstan. Nor was this the only form in which the mill-stones were made, for we have several actual specimens in existence of very ancient conical mills, which are the more interesting now as there are several conical mills lately introduced, and one of the most recent seems very likely to be generally introduced.

The construction of corn-mills for the manufacture of flour on a large scale cannot be considered, strictly speaking, as a portion of the regular business of the farmer, but as farms are increased in size, and a more regular system of machinery established in the steadings, and engines of larger power employed to drive it, there can be no doubt but that a properly constructed corn-mill, working two pairs of stones, will be constructed in every case; for although a number of ingenious mills have been invented, and are manufactured for the various purposes required by agriculturists, none of them can compete in efficiency with a pair of good burr-stones. It is true there is one great drawback in the use of stones, that is, the difficulty of dressing them; but in large farms employing a large quantity of machinery, one man will be required to devote himself entirely to the engine and machinery, superintending the driving it, and keeping it in order and repair: this man might soon acquire the necessary knowledge to dress the stones, as a part of his ordinary duties. I have no fear but that when a man of superior intelligence and character is required in the steading, and a little encouragement given in the shape of better wages, he will soon make his appearance. I have remarked that a knowledge of any new implement or machine is very quickly acquired by a smart agricultural labourer, and in a very short time he becomes

quite an authority about its characteristics, and the best time and manner of using it; he only requires to be properly instructed at starting, and practice will soon make him perfect. In all large steadings a pair of stones should be erected in a proper manner, that is pretty much the same as in small corn-mills, and attached should be a dressing and a smut-machine. A short description of these machines may be of value here, as this book is intended specially for persons in the colonies, who may not there have access to more elaborate treatises. As a foundation for the stones, and to carry the bearings of the machinery, it is usual to construct what is called the "mill-hurst." This is composed of iron columns and girders, if of iron, but as our object is to describe the simplest and cheapest, we will presume it to be made entirely of wood, and for two pairs of stones.

A solid foundation having been obtained, stout sills of oak are framed together, forming a parallelogram. Upright pieces are then placed at each angle, and lintels on the top, the whole mortised and tenoned together, forming a substantial frame, upon which the machinery is to be placed: across the top of the frame, in its shortest dimension, are placed deep pieces of timber as joists, called the stone-bearers; upon these are placed the lower stones, called the bed-stones; this is carefully laid, wedged perfectly true, and should be quite steady and firm in its seat.

Directly above the sill of the hurst in the centre, and crossing it, is introduced the driving-shaft, or as it is called by millers, the lay-shaft; one end of this runs in a plummer block securely placed on the sill of the hurst; the other usually passes through the wall of the mill, and is carried outside the drum which drives the mill, or if a water-wheel, it is the water-wheel shaft introduced into the mill as a lay-shaft at once. Upon this shaft, a short distance from the centre of the hurst, is placed vertically a large toothed wheel called the pit-wheel; the teeth are generally of wood

and work into a small horizontal iron toothed bevel wheel called the waller, placed upon the upright shaft; in the bottom of this upright shaft is an iron gudgeon which works in a solid brass bearing. As the centre of the upright is exactly over the horizontal centre of the lay-shaft, it is evident that some means must be adopted to carry it; the ordinary manner is to carry a bridge beam across the hurst lengthways; each end of the block is supported on a beam, which is tenoned into the uprights that form the hurst. The brass bearing on which the gudgeon of the shaft works is placed on an iron carriage fixed to the bridge beam, and is adjusted to a fixed centre by four screws on the carriage. Directly above the waller upon the upright shaft, is placed another wheel not bevelled, and much larger than the waller called the crown wheel. This wheel usually has wooden teeth, and these work into the teeth of the stone nut or pinion. Through the centre of the lower, or bed stone, is cut a circular hole, through which the spindle passes to carry and turn the upper stone, or, as it is called, the runner. The two stones are circular and of the same diameter, but the runner is usually much thicker than the bed-stone; these will be found described under the head of mill stones. The upper stone has a large hole cut through the centre and securely fixed; across the bottom of this is a strong iron bar or bearing iron; this is made square and bent downwards so as to form an arch. It is necessary in the process of grinding, that the upper stone should revolve with great velocity above the lower, not touching, but the distance adjusted with great nicety, as much depends upon it as to the sample of the flour when ground. We have before said, that through the centre of the bed-stone, there is placed the spindle, which is a stout bar of iron, the bottom resting upon a brass bearing, to which we shall presently allude, and on the top is a large boss of iron having a slot cut through large enough to admit of the bearing

iron before alluded to, dropping into it; on the top of the bed-stone, over the hole through which the spindle passes, is placed an iron plate, the upper surface of which is level with the top of the bed-stone; the lower surface of the boss on the spindle works down upon this and prevents the flour working through.

We have before remarked, that the space between the stones requires to be adjusted with great nicety; some arrangement must therefore be made to raise and lower the bottom of the spindle which supports the upper stone or runner.

In very old mills this is effected in a very simple manner; between the two upright posts that form the hurst is placed a beam, one end being formed into a large tenon and let into a mortise in the post. Through the post and the tenon is passed a pin, upon which the beam is supported and allowed to move; the other end of the beam is worked upwards and downwards on a slot, by a capstan-headed screw; on the centre of the beam is placed the brass bearing to receive the arbor of the spindle. This beam and the runner above are often regulated by a governor, which will be found described in the chapter on the steam-engine.

Upon the spindle is placed a small cog-wheel called the stone pinion or stone nut; the cogs or teeth of this wheel are placed exactly opposite the cogs of the large horizontal wheel called the crown-wheel, and from that it receives its motion.

We have now arranged the means of driving the stone pinion and the runner, and provided the means for regulating the action of the stones; but there is another provision to be made, that is, the means of disengaging the stone pinion from the crown wheel, so that one pair of stones may be run alone, or, if necessary, both pans disengaged and the upright shaft driven by itself for the purpose of working the machinery attached to it, and placed in the upper floors of

the mill. This is effected in the most primitive forms of mills by removing one of the wooden teeth from the pinion, the teeth of the crown wheel then passing by without touching; this is an exceedingly rude method of working, as the moveable teeth will soon become loose. A better plan is to have the pinion set on a square on the spindle, and by means of levers it rises up clear of the crown wheel, and remains so until required to be used. The description of mill we are describing is of the simplest form, which I think is therefore more likely to be understood by non-professional readers; but both for the purpose of lifting the runner and ungearing the pinion, beautiful mechanical contrivances are adopted by millwrights, which work with the greatest accuracy and facility, and I regret not having space to describe them in detail.

We must now proceed to the upper stage of the mill for the purpose of tracing the course of the wheat through the mill, until it leaves it in the shape of meal.

The wheat is placed in hoppers, which are conical-shaped boxes, having an aperture at the lowest point through which the wheat passes into shoots or spouts to smaller hoppers placed over the mill stone; at the lowest point of these hoppers is an aperture through which the wheat passes into a small spout open at the top and placed nearly horizontally; the lower hopper is placed on a framework which stands upon the wooden cover of the stone called the hoop. Nearly at the end of the small shoot is a hole through which the wheat passes into the large aperture in the centre of the runner; a jerking motion is given to the shoe by a peculiar shaped spindle, worked from the stone below. The wheat having now arrived at the grinding stones, some description of them is necessary before proceeding farther.

Mill Stones.—These stones are made of a variety of materials, of a stone brought down the Rhine and called peak stones, sometimes sienite or granite; but the

material that of all others is preferred is called burr stone: this is found in the mineral basin of Paris, and although an immense quantity of it is quarried, inasmuch as the revetment walls of the fortifications of Paris are made with it, yet it is only small selected pieces that will be found fit for mill-stones.

The burr stone is geologically the uppermost stratum of the solid crust of the earth, there being nothing about it but diluvial gravel, sand, and loam. The stones are quarried in the open air and sent to this country in pieces, where they are sold at so much per pound, the ordinary selling price being for good sorts, about *5d.* per pound. The mill-stone makers, in constructing the stones, which are often of large diameter, have to face a number of pieces, and assort them with great care; they are then cemented together with plaster and secured with iron hoops or bonds. Good burr, or, as they are often called, French stones, should exhibit a positively cellular texture, the cells being irregular in size and shape, and often cut transversely by thin plates of silex; it should be exceedingly hard without being brittle; the best stones are of a warm white or yellowish grey, and sometimes a tint approaching to blue.

The facing these stones is an important matter; they are first worked down to an uniform level, and narrow shallow chases are cut, radiating, though not directly from the centre; various arrangements of these channels (which are called furs) are made by different makers, but there is a fixed angle at which they are generally set out: they must on no account allow the centrifugal force to shoot the wheat through them to the outside, which I have known some arrangements of the burrs do; for if this is the case the wheat cannot be evenly ground. The surface of the stones between the furs will of course in the process of grinding wear smooth and assume a polish; as soon as this is apparent the face has to be chipped, or as it is called, sharpened or

pricked. This is done with a tool called a mill-bill, which is a double steel wedged chisel, ground sharp on a flat stone; this is placed in a handle, and the miller resting on the stone and supporting his hand on a cushion, keeps up a succession of sharp blows with the bill, making a small indented line or cut on the stone; these pricks or marks being close together and all over the surface of the stone, produce a texture or tooth which is the grinding power. The quantity of meal a given pair of stones will grind, as well as the quality of the meal, will depend a good deal upon the state of dress or surface the stones may happen to be in while employed.

To return to the operation of the grinding the wheat: after it is shaken from the spout it descends upon the centre of the lower stone, and passing outwards by the centrifugal force imparted to it by the rapid revolutions of the upper stone, it is ground between the two rubbing surfaces; the same force drives it, when ground, to the outside of the stone. Both stones are covered with a wooden circular framing called the hoop, the sides of this keep the meal from rushing outwards; between this hoop and the bed-stone is an aperture in the floor through which the meal passes by a shoot to the meal-bins below.

Wheat that has simply passed through the stones is in that state called meal, and not flour, till it has been dressed; for in the state of meal it of course contains the husks of the grains of wheat broken and bruised, but still mixed up with the flour. It is necessary, therefore, that the meal should undergo some other process by which the husks will be extracted. This is done by machines called

Dressing or Bolting Machines.—Bolting is the operation of separating by sifting the finer particles of the meal from the coarser. The machine consists of a cylinder formed of wood ribs; upon these are strained a cloth as fine as wire gauze, and of different degrees of fineness; within the cylinder, passing

through the centre, is a shaft, and upon this, at intervals, are placed radiating arms; extending the length of the machine upon these arms are spars of wood to which brushes are fixed the whole of their length; the cylinder is not set level, but at a certain inclination. The meal being admitted at the upper end of the cylinder, and a high degree of velocity being given to the brushes which revolve upon the horizontal shaft, the finer particles of the meal are forced through the finest gauze, and as it descends the sections of the cylinder, being covered with different cloths of different degrees of fineness, the particles of the meal are forced through the different sized meshes of the screen according to their sizes; the bran or husks, being carried right through the cylinder, and descend through an aperture at its lower end to a receptacle placed for them.

This ingenious machine was invented and patented by John Milne, A.D. 1675, and is thus described:—"A machine for dressing flour of wheat or barley, which will make a more lively and better flour than bolting-cloths (which is the common method now used), from the same corn. It will dress all sorts of flour, and divide the sharps from the bran at one operation, and the person that attends it may easily make two sorts, or only one, by moving the partitions that divide the flour, which must be within the box or case in which the machine works; and as flour is an article that loses every time it is stirred, it evidently appears that it dresses with less loss, because it does that business at one operation which, to be done with cloths in the common method now used, requires several operations and several different cloths, and the trouble of changing them, they being obliged to change their cloths for different sorts."

The patent was for brushes, either lying parallel to the axes of the cylinder, or formed like a screw or worm; either the brushes to revolve in the cylinder, or the cylinder to revolve also.

Very little alteration has taken place in the construction of dressing-machines since this patent; but a number of different plans are put forward by makers of corn-dressing machinery.

A variety of patents have been obtained by various persons, at different times, for improvements in the construction of corn-mills, but scarcely any have come into use. We will notice such as have been at all successful, and must pass over the infinite variety that have not.

Grinding with metal plates has been tried, and with some amount of success, by various persons, and Mr. Croskill's present eccentric mill seems likely to come into general use. The first of these mills worth notice is generally known as the French Military Mill, and was the invention of Francis Devreux, to whom a patent was granted for it in 1824. The principle is that of metallic groove plates turning on a vertical plane; the grooves cut radiating from the centre of the plate. One of the plates is fixed to the end of the frame of the mill; the other revolves upon an axis fixed in the centre of the fixed plate at one end, and in the side of the frame in the other.

The grain is fed through an aperture in the fixed plate, and having been subjected to the action of grinding between the two plates, passes through an opening at the bottom into a hopper, and thence to a bin. The manner in which the grinding plate was regulated in this mill was exceedingly well contrived, and was, in fact, the novelty, for vertical mills had been used before.

Sharp & Roberts's Mill. — Messrs. Sharp & Roberts received a patent for this mill, 1st Jan. 1834; it was the invention of a foreigner, and is novel and ingenious.

The object sought to be obtained in this invention was to increase the triturating effect of ordinary grinders, by placing the lower stone, which in this case is the runner, eccentric with the bed-stone, which is here uppermost.

The corn descended by a funnel through the centre of the upper stone or grinder (for the patent was for metal or stone grinders) into the lower, as in the ordinary mills, except that in the former case the pressure is upwards, while in the latter it is downwards. The lower stone or runner was supported on a vertical shaft driven in the ordinary manner, and the space between the upper and lower stone was regulated by a wheel and screw which lifted or depressed the cup in which the vertical shaft is placed. We shall have occasion hereafter to allude to this mill.

In 1835 Mr. Herbert took out a patent for an exceedingly simple mill for grinding and dressing flour. The corn is placed in a hopper, through the centre of which is a vertical shaft; on the top of this is placed, horizontally, a mitre wheel; across the centre of this is placed a horizontal shaft, having a fly-wheel at one end, and at the other the wind with which the motion is imparted to the machine. The mitre-wheel on the vertical shaft gears with a corresponding one on the horizontal shaft, and this motion is given to the grinder below, and some brushes contained in a circular box, the bottom of which is covered with moveable wire gauze. The flour as it descends from the stones falls upon the gauze and passes through to its receptacle beneath, while the bran is driven outwards by the action of the brushes, falling into a screen of coarse wire, where the bran is separated from the pollard.

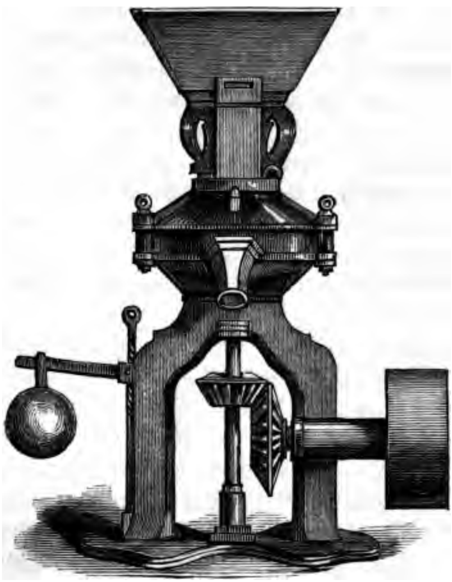
Another mill invented by Mr. Herbert, consisted of vertical grinding plates placed at one end of a dressing machine, the grinding apparatus being much the same as Devreux's mill, the vertical grinder running upon the shaft of the dressing machine. This is an exceedingly compact and effective machine, the various qualities of the flour and offal being deposited in their respective compartments, under the machine.

Croskill's Universal Mill.—This machine has lately been

introduced by Mr. Croskill, of Beverley, Yorkshire, and bids fair to become one of the most extensively used and useful machines that the farmer can have upon his premises.

The term "Universal Mill" is justly applied to this mill, for its grinding powers are almost unlimited; it is said to grind equally well ever so fine or ever so coarse. I have seen it employed in grinding raw flints, coprolites, quartz, bones, charcoal, paint, all kinds of grain, merely bruising, or making good meal. I think this machine quite capable of effecting all the different operations; grinding, crushing, bruising, or splitting, that may be required in the homestead;

Fig. 29.



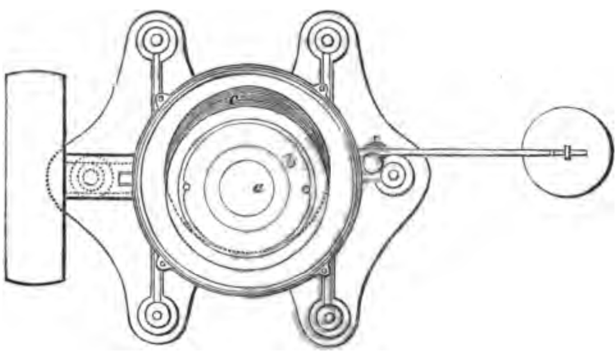
CROSKILL'S UNIVERSAL MILL.

the grinding-plates being varied according to the change of work.

Figs. 29, 30, and 31, represent an elevation and section

of the mill, the principle of which consists in *an upper and lower grinding-plate running in the same direction, and at nearly equal velocities, but not on the same centre;* hence it is sometimes called the eccentric mill. Grooves are cut in the surface of the plate in circles radiating from the same centre; these circular edges act like revolving shears,

Fig. 30.—Plan.



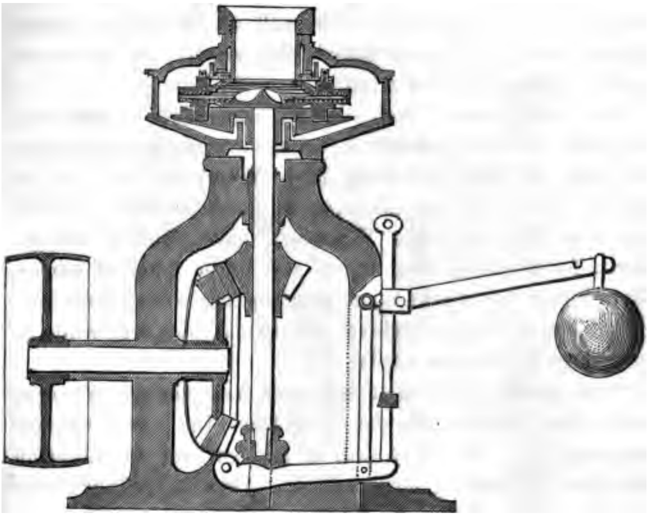
cutting every way, and producing a most perfect grinding or cutting action.

There is considerable similarity between this mill and the one patented by Sharp & Roberts in 1834: both are eccentric, but in Mr. Croskill's the action is much more perfect. This mill is exceedingly portable, and occupies very little space. In working, it should run to the right, and at a speed of not less than 300 revolutions per minute; and it may, if necessary, be run up 800. An arrangement is made to prevent accidents, by a guard lever which relieves the mill of any obstruction requiring greater power than crushing the material the mill is grinding. The weight is so arranged as to keep the plates up while grinding.

The distance between the plates is regulated by an adjusting screw, and the mill will thus grind coarser or finer, as may be required.

In removing the upper plate from the mill a lever is

Fig. 31.—Section.



placed in the hole in the ring which is on the top of the mill; this screws the ring off, and separates the plates: being a back-handed screw, for the purpose of keeping the ring on the tube while the mill is running. The following directions are given as to oiling the mill:—There are three principal places to be well supplied with oil. The first is the step in which the lower end of the shaft revolves; the second is the box which holds the shaft in its upright position: this is done by pouring oil through a tube which leads to the box; the third place is the upper bearing of the mill. In this is a large reservoir for holding oil; it is poured in through a tube just over the bearing of the mill. After it

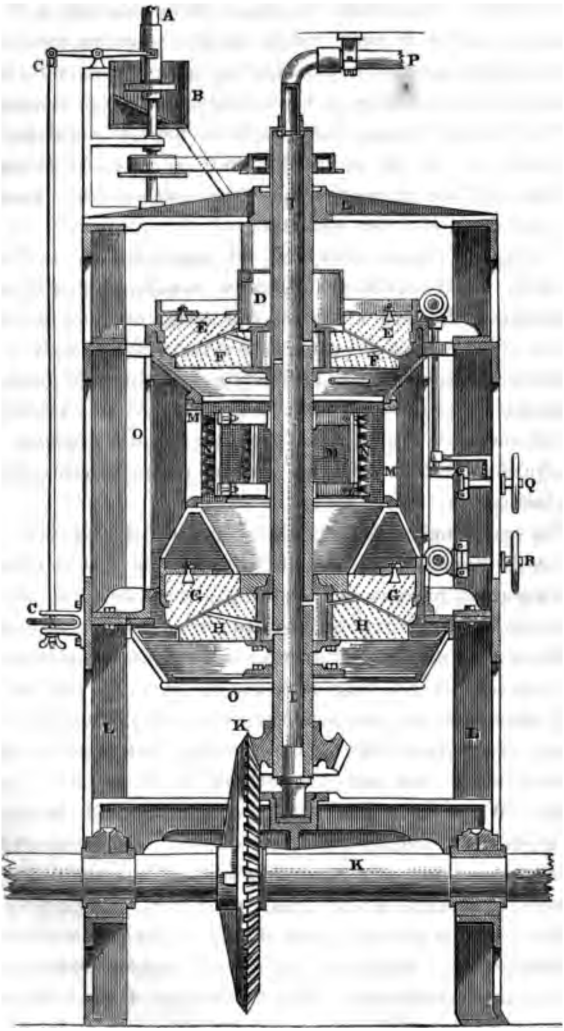
is supplied with oil, a stopper should be put in the opening to the tube to prevent the dust from getting in. The adjusting screw is held firmly in any position by a small screw against its side. The feeding is regulated by a shoe, acting against the tube of the upper plate, which causes the shoe to vibrate; this with the side of hopper regulates the quantity put into the mill. The mill can be taken to pieces, cleaned, and the plates changed, if necessary, for coarser or finer grinding, in a few minutes.

Westrop's Conical Mill, fig. 32, represents a section of this mill. As Croskill's is, in some measure, a modification of Sharp & Roberts's mill, so is Westrop's in a slight degree similar to one patented by Luke Herbert, in 1833, for both Herbert's and Westrop's have double arrangements for grinding, with upper and lower pairs of stones. Mr. Herbert's remarks upon grinding are so judicious, and his object so fully explained, that it may be worth while to give them in his own words:—

"In grinding wheat it has ever been the endeavour of millers to separate all the flour from the husk, without pressing it so hard as to 'kill it,' and without deteriorating its colour by making many minute 'greys.' This they have not been able to effect in a convenient or profitable manner with the mills constructed on the usual plan, nor by any form of construction that has hitherto appeared. The reason is obvious: if the stones be brought so close together as is necessary to remove the firmly adhering portions of the flour from the husk, the whole of it will be, in a great measure, 'killed' and discoloured by the violent rubbing necessary to clean the bran; on the other hand, if the stones are kept further apart, so as to 'grind high,' much of the flour will be left in the offals and bran.

"These disadvantages, which are inseparable from the old system, are completely obviated by the 'Patent Portable Progressive Corn Mill,' from the following causes: 'Instead

Fig. 32.—Section



WESTROP'S C NICAL MILL.

of employing only a single pair of stones of great weight and diameter, a progressive mill consists of *two pairs of stones of smaller diameter, with a flour-dresser between them,* into which the meal from the top pair of stones freely descends; two-thirds or three-fourths of very superior strong flour is thus at once produced, while *the unfinished portion falls into the eye of the second pair of stones* underneath. This second pair of stones are set closer together than the first, to complete the softening of the remainder of the meal, which, in consequence of the bulk of the flour being separated from it, is much more easily operated upon. Underneath this pair of stones is placed a common dressing machine, into which the meal falls as it is ground, where the remaining flour, as well as the different qualities of offal, are separated in the usual way." In Mr. Allen Ransome's "Implements of Agriculture" will be found a drawing and description of this mill, as well as many others equally interesting.

The principal difference between Westrop's mill and Herbert's lies in the shape of the stones. In Herbert's they were flat surfaces, in Westrop's they are conical, and not much different in principle from the ancient mill called the Pompeian mill, which ground by two conical stones, the lower fixed and the upper revolving upon it. It is 1700 years since the city was burned by the ashes from Vesuvius, during a terrible eruption, but there is a conical mill perfect, (truly the ancients left us nothing to do in the way of mills). We extract the following description of Westrop's mill from the "Illustrated London News" (supplement):—

"In presenting our readers with the subjoined plan of Westrop's Conical Flour Mill, we think it necessary to remark, that for the last three centuries our best mechanical millwrights and engineers have been seeking some better method of grinding wheat than by the use of the antiquated *horizontal* mill stones. These stones are most of them from

four to five feet diameter: and wheat passing between them in the operation of being ground into meal, is subject to such an amount of heat by pressure and friction, as to extract from it, by evaporation, a very considerable portion of its nutritious qualities: the stones being horizontal, the delivery of the meal after grinding can only be effected by the extreme velocity with which the upper stone revolves. Under the disadvantageous circumstances in which our older millers have worked for so many years, we cannot but hail an invention, as effective as it is simple, which completely provides against the evils which the old system is subject to. The improvement we refer to is the adoption of conical stones in lieu of horizontal ones, with a working surface of only 8 inches instead of 2 feet. By the first pair of stones the wheat is broken and delivered in a state of half-ground meal, unheated, and by the natural laws of gravity the flour is instantly passed through a wire cylinder fixed beneath, by the aid of brushes fixed upon the same shaft as the stones. The flour being thus instantly separated from the unground meal, the latter passes down to the second pair of stones, also fixed upon the same shaft, and the grinding is then completed. Moreover, we cannot refrain from expressing our admiration of the concise and beautiful adjustment of the stones, as being on a good sound principle. The lower, or running stones are keyed upon the shaft, whilst the upper or stationary stones drop into a turned ring, and necessarily rise and fall upon four inclined planes, and are capable of regulation to the utmost nicety, thereby wholly relieving the wheat from any undue pressure during the operation of grinding, whilst the weight upon the old system was equal to three quarters of a ton. Another feature of paramount importance is, that the conical mill can be driven by less power than is required to drive the horizontal ones, the former producing double the quantity of work in the same period of time. We have

perused certificates from several respectable bakers who have used the flour produced by this method, which state that a sack of flour manufactured by the conical mill will produce from two to three 4lb. loaves more than that which is made by any other mode of manufacture; and they attribute this increase to the greater quantity of gluten and nutritious qualities retained in the flour, from its being so much less heated, the wheat passing over such a small surface of stone.

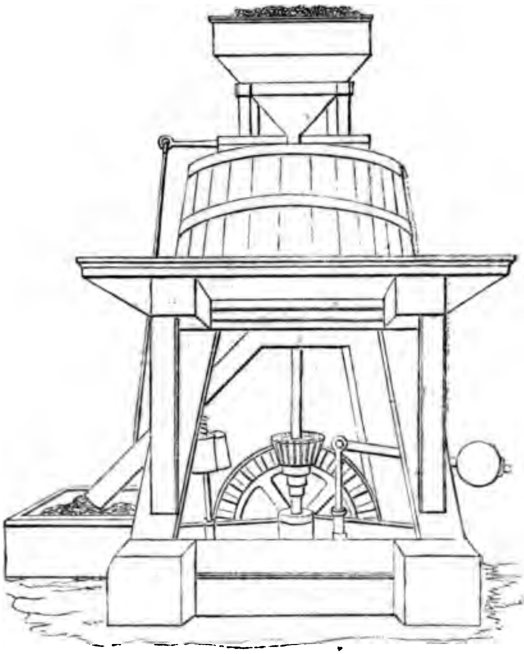
Reference to Plate.

A, Feed pipe.
B, Chamber containing the feed regulator.
C, Feed regulator.
D, Chamber over the eye of the stones which receives the wheat from the regulator.
E, Upper top mill stone (stationary).
F, Upper runner.
G, Lower top stone (stationary).
H, Lower runner.
I, Hollow spindle upon which the runners are hung.
K, Bevil wheels and driving shaft.
L, Iron frame sustaining the whole machine.
M, Upright wire cylinder acting as a partial dressing machine.
N, Brushes acting upon the wire cylinder M.
O, Wooden case enclosing stones and cylinder, to the bottom of which the spout is fixed.
P, Pipe to convey cold air into the face of the stones, the inside of the hollow spindle I conducting the air to the stones.
Q, Regulator for adjusting the upper pair of stones.
R, Regulator for adjusting the lower pair of stones.

Garrett's Stone Mill.—This is a most excellent mill for agricultural purposes, where a large quantity of work is required to be done in grinding wheat and other farm produce. The stones are 32 inches in diameter, and enclosed in a metal and wood framing. The top stone is hung on an upright shaft, and worked by a pair of bevil wheels, from

which the attachment may be made to either steam, water, or horse-power. Its construction admits of the stones being readily adjusted for grinding wheat, barley, beans,

Fig. 33.



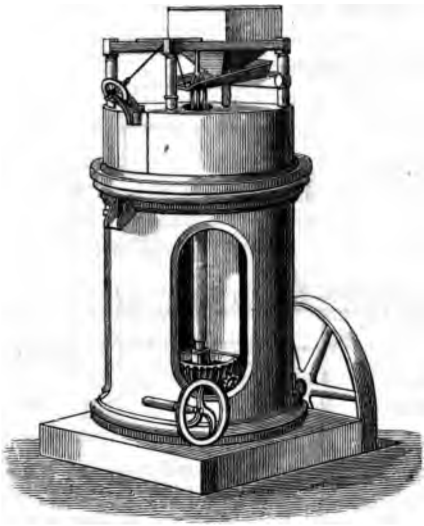
GARRETT'S STONE MILL.

or peas. The framework of the mill is most excellently constructed of timber of large scantling, and perfectly secured by iron bolts. It is in every respect a first-rate mill, and one that we specially recommend for farms of any magnitude.

Messrs. Clayton Shuttleworth's mill is similar to Messrs. Garrett's, only the frame is made of iron instead of wood;

the stones being supported on a handsome iron cylinder of good design, and inside which the driving gear is placed.

Fig. 34.



CLAYTON SHUTTLEWORTH'S STONE MILL.

It is in every respect a first-rate mill, and, as a piece of workmanship, does infinite credit to the firm that has produced it. They received a prize from the Royal Agricultural Society, at Exeter, 1850. At the Norwich meeting, 1849, the judges, after it had competed with thirty-two other mills, made the following report:—

"The portable mills, for grinding fine meal, did not possess much merit, with the exception of Messrs. Clayton Shuttleworth's, to which we awarded the prize. It both kibbled and ground in a superior style to any of the others, grinding barley perfectly well at the rate of six bushels per hour, without much heating the meal. It was upon the

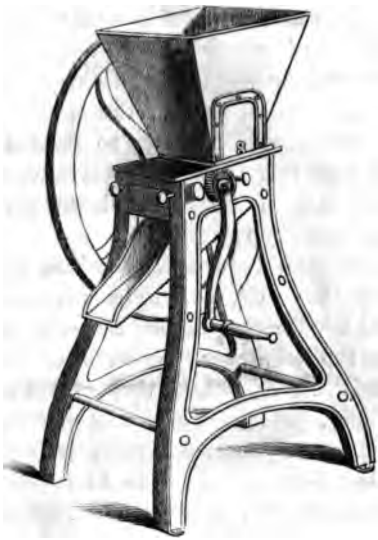
same principle as fixed mill-stones usually are, and well got up in point of workmanship, and took little room, so that we consider it a valuable implement. The stones are 2 feet 8 inches diameter, fixed in a metal cylindrical frame, 3 feet 6 inches diameter, and 4 feet 7 inches high from the floor to the top of the bed stone. The runner is driven by the upright spindle, which is driven by a pair of bevil wheels at the foot, one geared with wood. The pulley shown on the outside is for running the strap which may be taken direct from the engine driving wheel; the small hand wheel in front is for adjusting the stones to their faces, at such distances as they may grind the finest flour, or only kibble beans, peas, or oats. Six bushels of barley per hour may be ground to fine meal by this mill."

The mills we have hitherto described are all of much too large and expensive a character to be used on small farms, and yet small farms require exactly the same operation to be performed as the large ones. Small farms are at a great disadvantage in this respect, as they cannot get the work done so cheaply as their more fortunate brethren, yet have to meet on equal terms in market; they are, therefore, obliged to buy several small mills to effect the different objects. These are of immense variety, and made of iron, and at a very cheap rate, and sold by all agricultural machine makers.

It is a most desirable thing to have a low priced mill that shall, by an alteration of grinding parts, perform the different operations of grinding meal for feeding stock (flour is better not attempted), and crushing, kibbling, splitting, or bruising, as may be required. Several attempts have been made, and, in some cases, with considerable success; and, in one I have remarked, it has answered capitally. It is manufactured by Barrett, Exall, and Andrewes, of Reading, and the difficulty we have noticed is overcome by having a double feed of exceedingly simple contrivance.

Fig. 35 represents the mill, which consists of three rollers parallel to each other, the two front ones slightly grooved; these are for crushing malt, oats, barley, and linseed, and are adjusted by two hand-screws. The back roller is cut

Fig. 35



BARRETT, EXALL, AND ANDREWES' PARAGON MILL.

for beans, and works against a plate as in the post mill; thus there are two separate mills in one, each fitted for its particular kind of work, and independent of each other.

An iron shifting-plate regulates the feed to each opening as it is required.

This mill will crush about four bushels of barley or oats per hour, or about one of linseed and six of beans.

Wood's Crushing Mill.—In this case the crushing is

performed by means of a large wheel four or five feet in diameter, acting against one of as many inches. It is adapted for a variety of work. As it is rather a favourite mill several varieties are manufactured by different houses, but all using the large wheel against the small one.

Fig. 36.

DEANE, DRAY, AND DEANE'S DOMESTIC FLOUR-MILL.

Fig. 36 represents a small hand-machine called the domestic flour-mill, well adapted for emigrants and cottagers. A small, convenient, and cheap flour-mill, has long been a desideratum. Messrs. Dean seem to have supplied it; for this little mill does its work in a very superior manner, the meal being perfectly soft and fine as from a large mill; it also dresses and separates the flour, seconds, and bran, at the same time, and in a manner we should not

have expected in so small a machine. It is constructed in an exceedingly compact form and is very portable.

Crushing-mills.—A variety of machines are constructed for crushing linseed and other grain, as well as for breaking the cake, either as food for stock or as manure.

Messrs. Garrett have produced a powerful machine for the purpose of breaking cakes of any size or thickness: it is fitted with two sets of barrels, which may be adjusted as required, to break cake into different sized pieces for bullocks or sheep, or powder for manure.

A screen is fixed between the barrels, through which as much of the cake as is sufficiently broken in passing through the first is sifted, to ensure uniformity of size, and avoid the unnecessary labour occasioned by that which is sufficiently broken passing through the bottom rollers with that which is not.

Cake-breakers are made in a simple and cheap manner by nearly all implement-makers, and the action is in nearly all cases effected by two grooved or notched rollers.

Bone-mills.—The steading which has a properly fixed steam-engine, has a great advantage over those which have not, as there are a number of operations that can be laid on the engine that could not well be effected by horse-power. Among these, the grinding of bones for manure is an important one, bone-dust having become one of the favourite and most generally used artificial manures, and should be purchased by the agriculturist in a state that he can himself judge of the quality of the article he is purchasing. If he buys bone ready ground he will have great difficulty in doing this. It is, therefore, necessary that he should buy them unbroken and grind them himself. Experiment, it is said, proves that bones that have been boiled are just as good for the land as bones upon which the fatty, fleshy, and fibrous matter remains. This I do not believe, if the result be taken at the end of several croppings;

but I do believe that the boiled bones are taken up as food by the plants much quicker than the others; and, as a quick return is most wanted by the farmer, there is no doubt that boiled bones ground into powder, and drilled in with the seed, is the best possible method of using this valuable and highly fertilising manure. I have alluded to the using green or boiled bones because (admitting the necessity of the steading being provided with a bone-mill) a very much simpler form of mill will do for the dry bones than would be required for the green.

Bone-crushing is at present done quite as a separate business, and the mills are large and expensive; but I see no reason why a small bone-mill should not be constructed adapted to large steadings. At present I do not remember to have seen such an one, but possibly they may be to be had.

Bone-grinding is effected by passing the bones through a series of toothed rollers arranged in pairs, the rollers being toothed or serrated in different degrees of fineness, and riddles are provided for sifting the bones into sizes, and they are then sold as inch, three-quarters, half-inch, and dust.

It is in the latter state that the farmer is most open to be cheated by dishonest dealers; and, therefore, half-inch bones are often preferred, not because they are so economical or so immediate in their action as drilled bone-dust, but because the buyer can better tell the quality of the article. A variety of different materials are employed to adulterate bone-dust: such as the refuse lime of tan-works, after it has been employed in removing wool and hair from the skins. This is passed through the rollers along with the bones, and as it has a strong pungent smell it is easily mistaken. Doubtless this material is a fertiliser, but if it is it can only be in a small degree, and is certainly a robbery on the purchaser of bone-dust. Old mortar, soap-boilers' waste, saw-dust, slaked lime, rotten wood, and a variety of other

materials are used to deceive and rob the farmer: hence I conceive a small cheap bone-mill to be a necessary machine to farms of any magnitude.

Cyder-mills.—The manufacture of cyder, in the apple-growing countries, as Herefordshire, Devonshire, &c., is an operation of great importance, and conducted with all the care and attention that is bestowed upon any other process for converting the produce of the land into a marketable commodity. Cyder is made from the juice of fruit expressed by the action of a powerful mill.

Cyder-mills are often constructed by setting up a single or double edge runner on either side of an upright shaft, which is turned by a horse working in a track; but several cyder-mills have been constructed on the principle of screw-presses. A silver medal was awarded to Mr. Alexander Dean, of Birmingham, for a new cyder-mill at the Royal Agricultural Society's Meeting at Derby. It was the invention of Mr. Ashwood, of Bretforton, Worcestershire, and is thus described in the Journal:—"This implement is, in fact, a crusher or squeezer, being furnished with a piston worked horizontally in a substantial wooden box, from which the apples are discharged in a state of pulp. Mr. Ashwood describes its mode of use thus: 'I drive it by a one or two-horse-power used for chaff-cutting, &c., and place it as near the cellar as convenient. It requires two women—one to carry the fruit from the heap and throw it into the hopper, the other to regulate the feeding with her hands; two men to remove the pulp and press it through hair cloths, the same as with the old mills, and one to carry and tun the cyder. The quantity of fruit it is capable of reducing varies according to its ripeness, from 300 to 400 bushels per day, and produces from 800 to 1000 gallons of juice. Several of my neighbours have already bespoken the use of my mill for the present year, who have seen the efficiency of its work, and the peculiar way in which the cyder keeps from

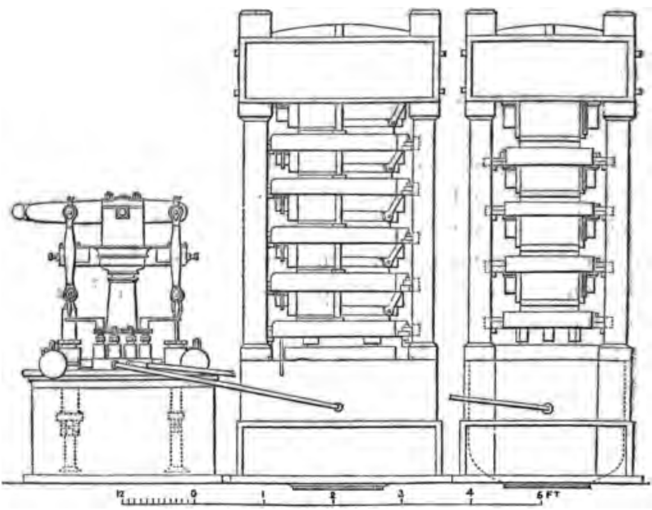
it. I also tried it last winter for pulping turnips and potatoes, for pig-feeding, and found it most economical. The juice is not squeezed out by it, but the pulp is beaten up to about the consistence of paste, which I mix with barley or bean meal, and find the pigs feed much faster than when mixed with water.' This new machine was very well got up by Mr. Dean, and accommodated to manual as well as animal or steam-power. It has been represented to the judges that the grating of apples is much preferred in America for cyder-making to the old rolling-mill; the saccharine matter being much better evolved by grating, and the pips in a great measure reduced."

In Fullerton's Agricultural Encyclopædia, I find the following description of one of these grating cyder-mills exhibited at the Massachusetts Agricultural Society; it is thus described: "It has a wooden cylinder, upon the surface of which nails are fixed; the heads are sharp upon the edges and project above the cylinder about one-eighth of an inch. The apples are filled into a hopper placed over the cylinder, and led into a narrow cavity at the upper side of it. The cylinder is mounted on a high frame, its axes being placed in composition boxes. A rapid revolution is produced by connecting it with a horse-mill by belts or bands. The apples are reduced to a fine pomace, grated, not pressed. It performed well in the presence of the committee, and grated a barrel of russet apples in 1 minute 34 seconds."

OIL-CAKE PRESS.

This, like the bone-mill, is a most important machine; for the cattle-feeder is cheated more in this article than any other. The common oil-cake sold for feeding stock is often adulterated with all sorts of rubbish. It ought to consist entirely of oil seeds, freed from a large proportion of their oil. When farmers have erected oil-expressing machinery, and made their own cake, an immense advantage has always

Fig. 37.



BLUNDELL'S HYDRAULIC CAKE AND OIL PRESSES.

been gained. And now that the culture of flax is likely to become general, the use of cake will also be more common, and the manufacture of it on their own premises be the common practice, as they will be enabled to get a much

richer cake for the same money. At present, the cake-presser's whole object is to extract as much oil as possible from the seed, for he gets just the same price from the farmer whether he extracts little or much; and certainly much of the cake imported into this country is so squeezed that little is left for the stock: and, not content with extracting every particle of oil, they recommence with downright adulteration, making the cakes up again for market.

Oil-cake presses are manufactured by Croskill, and most large concerns. Fig. 37 represents the patent hydraulic presses of Martin Samuelson & Co., of Hull. One press holds ten cakes of 3lb. each, and the other four cakes of 8lb. each.

The presses are easily fixed, and the wear and tear is trifling, being confined chiefly to the leathers of the pumps and the cylinder rams.

The pumps are made of gun metal, and, as well as the presses, are of first-rate workmanship. The great advantage of these presses over the ordinary stampers is in the increased quantity of oil extracted, and the extra amount of work that can be done.

SACK-HOISTING MACHINERY.

Presuming farmeries to be constructed in their arrangements something more nearly to mills and manufactories, there will be required an easy method of hoisting sacks and other weights from the lower to the upper floors, or granaries. A common crane and windlass is often used, but this is an exceedingly slow process, and not always convenient.

In flour-mills it is necessary to have the means of hoisting with rapidity and ease the sacks of corn from the lower floors to the higher, for the purpose of emptying it into the hoppers for supplying the stones; or to raise the meal from the bins on the lower floors to the upper, to be passed through the dressing-machine; and for this purpose a machine, called a

sack-tackle, or hoist, is used. It is exceedingly simple, and answers the purpose admirably.

Sack-tackles are constructed in several different ways, but the one most in use is as follows :—

In the roof of the mill (though it might be in any other convenient place) is placed a wooden framework, moving with hinges at one end; across this frame is placed a shaft, or spindle, having upon it a wheel, or pulley, and a barrel to carry the chain or rope; in a line with the pulley, in some direction, and upon a shaft always kept running, is placed another pulley; over these two pass a strap, made so loose that the pulley in motion does not give motion to the other. At one end of the sack-tackle frame is a piece of iron, set up with a strong spring to press it forward, and having a projecting notch or ledge on the face of it. We have before observed that one end of the frame was moveable; when a sack is required to be hoisted, one end of the wooden frame and with it the shaft carrying the pulley and chain-barrel is lifted; the strap then works tight on both the running and the other pulley, and the chain or rope works round the barrel. The frame is lifted by a cord running through a small pulley above, and passing through a hole in each floor beside the sack-traps, through which the sacks are hoisted; when the frame is lifted by this cord, it passes up the face of the iron spring till it arrives at the notch, upon which it rests. The cord by which the frame is lifted is called the striking-in line. As long as the frame remains on the notch, the barrel continues to revolve and wind up the chain. There of course requires another arrangement to again slack the strap and stay the action of the winding barrel; this is effected by simply having a line to draw back the spring, upon which the frame descends to its former position. This line is carried down through the floors beside the other, and is called the "striking-out line." At the lower end of the chain is a ring large enough to admit of the slack being passed through

double; a loop is thus formed which takes hold of the neck or tie of the sack; the striking-in line is pulled with a jerk, and the sack ascends to the required height; the striking-out line is then pulled, and the sack drops on to the floor above the traps.

In some sack-hoists the strap is tightened by a lever pressing against it; the frame and barrel then being stationary, nothing taking place but the tightening of the strap by the lever. In others, a hollow cone is used, working on to a solid one, which is always moving; but the ordinary one we have attempted to describe.

CHAPTER X.

MACHINES USED IN PREPARING FOOD FOR STOCK.

The Chaff-cutter.—This machine has only been introduced of late years in an effective state, although the cutting of plants and leaves as food for stock is spoken of by the earliest writers. The chaff-cutter first used in this country, and only introduced so lately as the close of the last century, consists of a plain box or trough, placed on four legs, and fitted with a large knife or blade, one end of which was secured to the end of a lever, and the other had attached to it a handle. The material to be cut was placed in the trough, and pressed, in small quantities, forward by means of a fork secured to the fore-end of the box by a chain, where it was cut off in determinate lengths by means of the knife, which the operator worked with one hand while he forced the straw, &c., forward, to be cut with the other. This plan will be recognised as the old well-known hand chaff-box, though now superseded by better contrivances; it was nevertheless an ingenious and effective machine.

The first chaff-cutting machine deserving the name was invented by Robert Salmon, of Woburn, many of whose inventions in connection with agriculture have since been adopted and carried out with great success. This machine of Salmon's was a large and cumbrous affair, but was, nevertheless, effective. It consisted in placing between the bellies of two wheels, and thereby connecting them together, a series of flat blades, the edges of which were fixed at an angle of 45 degrees from the plane of the wheel's motion. The knives in revolving are brought against the material to be cut at an acute angle, so preventing anything like a sudden blow. The straw was fed through a trough, and between two spiked rollers turned by ratchet wheels on the outside, and so arranged that the straw should be at rest while the knife was passing through it. It is quite evident that this is the original of a very large class of machines until very lately in common use.

Pasmore's engine was only a modification of Salmon's, which it considerably improved. In this case the knives were reduced in size, and the whole simplified, the feed better arranged, and the whole machine constructed in a much more mechanical manner.

Lester's Machine.—This was patented in 1800, and upon the principle now generally adopted, that is the placing the knife upon a fly-wheel. From this point, the chaff-machine has been rapidly improving: the earliest made had an endless web of cloth passing over two rollers, and carrying forward the straw, which was compressed by a heavy block of wood; both this and the endless cloth are now dispensed with. It was an effective engine, but consumed great power in working.

Heppenstall's Chaff Engine.—This was patented in 1818, and was on the same cutting principle as Lester's, but several improvements had been made in the feed; it consisted in the application of a worm to turn the two feeding-

rollers, which convey the straw to be cut to the two knives, which are placed upon two arms of the fly-wheel.

Ransome & May's Chaff Engine.—Lester's principle was entirely completed and carried out by Mr. May, and is thus described by Mr. Ransome in his valuable work, "The Implements of Agriculture:"—"The Chaff Engine patented by Mr. C. May is a successful attempt at combining the advantages of some of the older plans with the power of altering the length of the cut; and also avoiding the difficulty of supplying the material to be cut, so evenly, that it may be delivered at the mouth pressed so close as to stand against the knife. The alteration of this length is accomplished by adding a second shaft, placing the screw which impels the rollers upon one shaft, the wheel carrying the knives upon the other, and connecting the two by toothed wheels of varying diameters, and capable of change at pleasure; this produces a variable rate between the velocity of the rollers and the revolutions of the knife-wheel, and the hay or straw is cut into lengths proportionate to such variation. By means of a plate called the presser the material is secured close together, and this plate, in the patent engine, instead of being fixed to the support of the upper roller, has a motion round the axis of it; and thus, if the feed is thin, the presser follows down, or if thick, rises up, so that at all times the proper pressure is supplied." The parts being strongly constructed, a considerable velocity may be given to the wheel carrying the knives. This engine is the one from which all the modern machines have been more or less copied. Messrs. Ransomes have not been behind-hand in improving their machine; since its first introduction many important alterations have been made to make it cut inferior material, and prevent it choking, as well as to enable the machine to be run at a higher velocity.

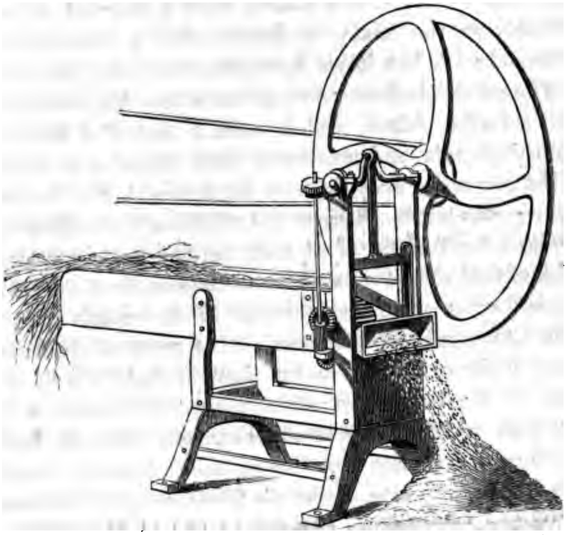
The Uley Chaff-cutter.—This machine was patented by Lord Ducie, in connexion with Clyburn & Budding,

engineers, of Uley. It is said to have performed its work admirably on the trial; its construction is thus described by the judges of the Royal Agricultural Society, Edinburgh: —"The cutter consists of two series of thin blades or knives, with serrated edges, coiled spirally round a horizontal rotatory cylinder, and presenting their edges at an angle to it; the one series is coiled from left to right, and the other from right to left, meeting in the middle of the cylinder: an unbroken continuity of cutting action is thus attained. A pair of feed-rollers is driven from the spindle of the cutting cylinder, which again gives motion to an endless cloth, by which the supply is maintained. The speed of the feeding-rollers is regulated by a highly ingenious and simple application of the worm and wheel. The wheel fixed on the roller is so constructed as to admit of being driven by worms, with threads varying from one to four; thus by changing the worm on the axis of the cylinder (which is also accomplished in a dexterously mechanical manner) the hay or straw is cut into lengths of from a quarter of an inch to one inch. This machine may be worked by manual, animal, or steam-power with equal convenience. Notwithstanding the favourable impression it made on first being introduced, it has not come into general use.

Guillotine Chaff-cutter.—This ingenious machine is the invention of Mr. Gillett, of Brailes, near Shipston-on-Stour, Warwickshire. (See fig. 38). It is a strong, well-arranged machine, and I have seen some that have been at work for a long time, giving great satisfaction: the whole machine is constructed of iron, runs very steady, and is exceedingly neat in appearance.

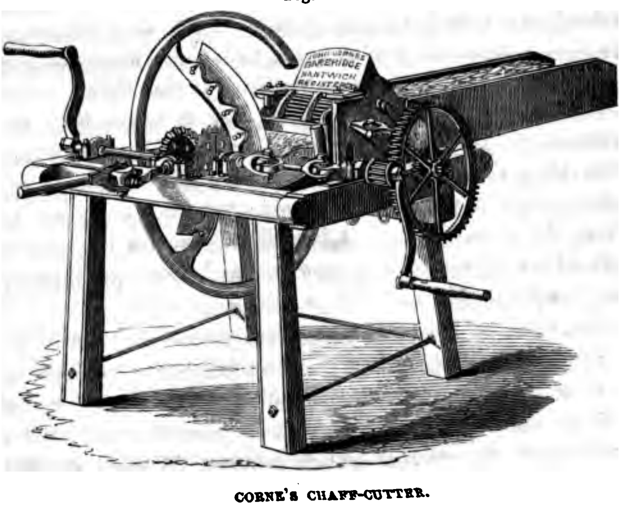
Corne's Chaff Machine.—This form of chaff machine seems to be preferred to all others; a great number of prizes have been awarded to it by the Royal Agricultural Society, as well as many local societies; it is manufactured under arrangement by several other makers, Messrs. Barrett,

Fig. 38.



GILLETT'S GUILLOTINE CHAFF-CUTTER.

Fig. 39.



CORNE'S CHAFF-CUTTER.

Exall & Andrewes, Hornsby, and others; it is fitted up with double gearing, to be worked either by two men or machinery; it cuts with three knives, breadth of cut 12 inches, depth 3½ inches, and makes one length of 4 inches for litter; a pair of rollers are also added to regulate the entrance of the material to the front rollers, next the cut, so getting rid of the danger likely to accrue to the persons feeding, by getting their hands entangled in the hay or straw when the machine is running at a high velocity. It cuts gorse or furze well $\frac{1}{8}$ of an inch long.

Richmond & Chandler make an excellent machine, with a most effective feeding apparatus, consisting of toothed rollers working into each other in such a manner as to ensure a regular feed, and prevent all choking; it is fitted upon a gothic pattern frame, securely made, and is in every respect an excellent machine.

Messrs. Barrett, of Reading, construct an exceedingly well-framed chaff-cutter, adapted to run at high velocities, entirely constructed of iron, and well arranged. The great difficulty in constructing an efficient chaff-cutter consists in getting it to feed equally well with all descriptions of material. A person unacquainted with these machines, and judging only from their performances at the shows, would be very liable to be deceived, as the material they are generally exhibited cutting is chosen for the special purpose, long, dry, crisp straw or clover; the very worst will appear effective when so employed; yet when badly got or damp hay is substituted it immediately makes its appearance where it should not, upwards and sideways, through the collar. If the machine is still kept going when this occurs, that portion of the machine which holds the straw to its work will be broken off, and as it is cast-iron cannot be repaired—the machine must remain idle till a new one is obtained from the maker. All badly-contrived feeding rollers will allow damp hay or any similar material to turn

round just before it is delivered to the knife, in passing round or between the feed-rollers and the end of the box; the reverse way, it meets the material coming in the opposite direction; a few turns more, and a general choke takes place; another turn or two, and some portion of the machine gives way. I have seen this happen over and over again when the common cheap machines have been attached to an engine of any kind, and an attempt made to run them at high velocities. If a large quantity of chaff is consumed, and the machine is to be worked by steam or water-power, it is always best to get a large well-framed machine adapted to the purpose. Such are made by all the principal makers, and if they guarantee them they may be relied on.

Messrs. Barrett have attempted to get a better feed in a totally different manner, by dispensing with the feed-rollers altogether, and substituting in their place a double endless chain, with circular bars extending across the box between the chains. The chains work over pinions at each end, and are in contact with the material to be cut their whole length, which is the improvement, as the rollers only hold between points. This machine was exhibited at the Smithfield Club Show last Christmas, and is the latest improvement I know of in connection with chaff machines.

It has long been a desideratum to have a machine that shall cut long lengths of straw for litter in an efficient manner; and though so many machines are advertised to do it, I do not see any that I could recommend for that purpose. I remember to have seen one a few years since, I think made by Smith, of Stamford, in which a moveable mouth-piece in front of the box carried forward the length of straw to be cut. This machine seemed to answer very well; but I have entirely lost sight of it, so I presume it did not answer. In Scotland, a machine is used for cutting straw, called the Canadian straw-cutter, and does its work very well;—two rollers, one plain and the other fitted with

knives, set lengthways of the roller, and radiating from its centre. These knives, as the roller revolves, press upon the cylinder below, and cut the straw into lengths equal to the distance between the knives. The feed is in the ordinary manner, through a box—the two rollers drawing it forward, without any other assistance.

I have heard this machine spoken very highly of as working very light, and cutting well; but I cannot consider the principle of cutting by pressure nearly so good as to give the knife a drawing motion, as is effected in every other machine. The lower roller must wear out rapidly, and there must be some difficulty in taking out the cutters to be sharpened or repaired.

TURNIP-CUTTERS.

The general culture of the turnip in this country is of so late a date, that this machine must, of necessity, be one of recent invention. When turnips began first to be used as food for sheep, a peculiar shaped hoe was all that was employed to cut them up into small dimensions. When they became a part of the food of the fattening oxen tied up in stalls, or of cows, a sort of chopper was used;—two or three turnips being placed on a block, the upper surface of which was slightly bevilled, and the turnips chopped into irregular pieces, as they rolled down the face of the block. These turnip-chopping blocks are still used by some old-fashioned people in the upper parts of Norfolk.

There are three different forms of turnip-cutters in use at the present time; one is the placing knives on a disc; another, knives placed on a cylinder; and lastly, knives working through a grating by a crank motion.

In the first form, a series of knives are placed in the face of an iron disc by screws. The turnips are placed in a hopper set at an angle, so that they may press by their own weight against the disc.

The knives are of two kinds; one flat, and extending from nearly the axle to the outer edge of the disc, and at a distance from it equal to the thickness the slice of the turnip is required to be.

If only slices are required of the full breadth of the turnip at the part it is cut, then this knife is used by itself; but if it is necessary that the turnip should be cut into sections the cross way of the cut, as for sheep, then a series of small knives, projecting from the face of the disc at right angles, are placed at distances apart equal to the width required. The pieces, after being cut, fall into the receptacle beneath.

Sometimes the disc is set horizontally, and the hopper above. I have seen very good turnip-cutters constructed upon this plan. Occasionally the disc is attached to a barrow or a cart.

The turnip-cutter that seems to be most approved of is known as Gardner's, and is now manufactured chiefly by Messrs. Samuelson, of Banbury, and is shown in figs. 40 and 41.

Fig. 40.—Section through the barrel and hopper.

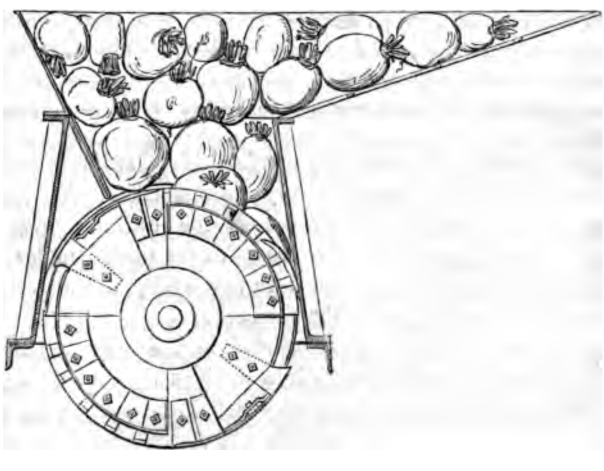


Fig. 41 represents a general view of Gardner's machine; and fig. 40 a section through the cylinder and hopper, showing the cutting principle. Cylinder turnip-cutters

Fig. 41.

SAMUELSON'S IMPROVED GARDNER'S TURNIP-CUTTING AND SLICING MACHINE.

were in use in Scotland long before Mr. Gardner's patent, but they only cut large and very unequal slices. The knife in them extended entirely across the cylinder with an unbroken edge, and had the cross knives placed under the slicing knife, of which there were two, and raised above the cylinder the thickness of the slice cut.

Gardner's improvement consisted in the arrangement of the face of the cutting-knife into sections of a width equal to the required cut of the root,—each knife cutting on the

front and side edge at right angles with it, and placed one above another till they meet in the centre, the angles of the knife retiring *en echelon* from the front to the centre. Two of these knives are placed on the cylinder in the cut, and against the front plate is shown a ledge, which causes the last piece of the turnip to be cut instead of falling through unslit. This is a recent improvement of the Messrs. Samuelson; and with some minor improvements in the detail, they have rendered it a perfect machine for its purpose; as it is a matter of great importance that the whole of the turnips should be cut into equal sized pieces, as nearly as possible, whatever the size may be, and not pass a large portion of thin edges or little angular pieces of slices; as when this is the case, great waste must, of necessity, ensue.

Messrs. Burgess & Key, of Newgate-street, are the patentees of a turnip-cutting machine, which I think an exceedingly good one. It is of very simple design, and is effective. It cut for sheep 3½ bushels in two minutes, at the trial of implements at the Great Exhibition, and was awarded a prize-medal. Two or three sizes can be cut at the same time, and each size be deposited in its separate receptacle; and a boy can work it.

All other roots, as mangold-wurzel, carrots, &c., and also chicory, may be cut with it equally well.

The principle upon which the machine acts is something similar to the machine formerly used in Scotland, and called the gridiron turnip-cutter; but only like in principle, as that was an exceedingly clumsy and rude affair, while this is an effective machine. In a long horizontal hopper are placed the turnips to be cut, and through the bottom of the hopper are a series of knives and guards, arranged to cut the different sizes. Motion is given by means of a crank to the knives in the hopper. This machine is well adapted for performing a large quantity of work in a short time; and is

not more expensive than other machines of the same capabilities.

GORSE-MACHINE.

Gorse, whins, or furze, as it is occasionally called, is an exceedingly valuable substance as food for stock.

In the northern districts of Wales it has long been used as food for horses and other animals, and with milch cows the most satisfactory results have been obtained, as it imparts to the milk and butter a fine colour and rich flavour, and cows are said to be more profitable when fed with it, than with hay or turnips; but it is as food for horses that it is mostly used in Wales; it is said that in Carnarvon and Anglesey, and in a portion of the county of Denbigh, four-fifths of the farmers, innkeepers, and public carriers, who keep horses, are in the habit of using gorse as provender to a great extent, and with signal advantage.

Notwithstanding the acknowledged value of this plan, comparatively speaking, it is scarcely introduced in England as food for stock: occasionally some gentleman tries it, but tenant farmers generally have not adopted it, and chiefly on account of the difficulty of bruising the prickles of the plant, in which the nutritive juices are enclosed. In the localities mentioned, various plans are adopted, the most simple being that of the chopping block and mallet. The block is set up perpendicularly, and an iron hoop fastened round the top, above its surface, and about two-thirds round. The mallet is a round piece of wood nine inches long, and four and a half diameter; one end is armed with a knife, and the other end is studded with nails, the knife projecting from the wood about three inches; both ends are secured by an iron band. The gorse is placed upon the block and chopped with the mallet into short lengths, after which it is bruised with the other end of the same instrument.

Another plan, on a larger scale, is to subject the gorse to

the action of edge stones, similar to a cyder mill. The gorse is most effectually bruised by this means. A regular mill is sometimes constructed in the following manner, and similar to a bark mill. Three or four rows of strong angular pieces of wrought-iron are fixed in a horizontal shaft; the rows are generally from two and a half feet to three in length; the teeth in the rows are about six inches long, clear of the shaft, which is placed inside a strong wooden box, formed of three wooden beams, each fitted with a row of teeth, similar to those on the shaft between which the latter pass as the shaft revolves, crushing the gorse most effectually, by reducing it to a pulp.

Wedlake's gorse-machine is very like this, only on a small scale. Decidedly the best machine hitherto invented is the one manufactured by Barrett & Exall. I have tried

Fig. 42

this machine myself, and can testify to its thoroughly accomplishing its purpose, the gorse, after having passed through, being quite soft like moss, and cattle that may

never have tasted it before eat it without the least inconvenience. Fig. 42 represents the exterior view of the machine; in its action it first cuts the gorse as chaff, by means of six knives placed on a drum, and afterwards compresses it between two rollers.

Potato-Separator.—This is a machine used for the purpose of separating potatoes into sizes ready for sale, and used for the different purposes to which the root is applied.

It is an exceedingly useful machine on those farms where potatoes are largely grown, and getting them properly sorted will ensure the farmer a greater profit than selling them mixed large and small, as the difference of price is greater for the superior class than is allowed for to the grower, a profit being always afterwards made by sorting, which ought to be got by the farmer.

Potato-separators have usually been constructed with three sieves or screens of different sized meshes, placed one under the other with a shoot to carry the potatoes from each screen to a separate receptacle; but Mr. Daintree, of Somersham, Huntingdonshire, has introduced an entirely new description of machine, exceedingly simple in its action, as, by one simple rotatory motion, which can be performed by any boy or woman, the potatoes are separated into three sizes, with much greater regularity than can be effected by any other means. The screen will entirely free them from all dirt, straw, or any other rubbish.

Root-washing Machines.—If machines are not provided for this purpose, the general business of the steading will be found to be conducted in a slovenly manner, as I know of nothing more indicative of it than to see stock feeding from roots covered with dirt; yet how often is it the case! Look at the state of the potatoes preparing for the hogs in many farms. Does the feeder imagine the animal is to get fat on dirt?

An ordinary practice is to put the roots into a large tub

filled up with water, and with a stick stir them about. It is true roots *may* be thoroughly washed by this means; but it is equally true they *never are.* There is no use doing the thing badly when such capital machines as those constructed by Richmond & Chandler and Crosskill are to be got at moderate prices.

Richmond & Chandler's machine consists of a cylinder formed of narrow bars, into which the roots are placed; the cylinder is supported at each end of an iron water cistern, in which it revolves by the action of a winch at one end. A portion of the cylinder is moveable, for the purpose of admitting and withdrawing the roots. At each end of the water trough is a rack set at an angle of forty-five degrees, and near the top of this rack it is curved nearly to the horizontal.

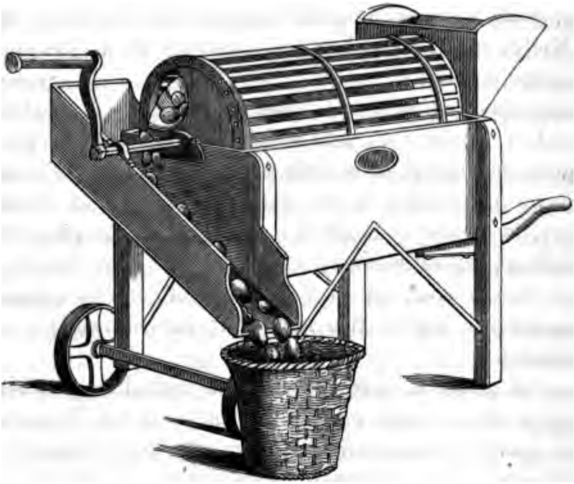
On the gudgeon that supports the cylindrical washer is placed a pinion, which gears in the rack. A simple arrangement enables the operator (after he has revolved the cylinder sufficiently often to cleanse the roots) to strike in gear the pinion with the rack; the cylinder is then lifted up to the horizontal part of the rack, where it remains while being emptied into a trough or barrow.

Crosskill's Archimedean Root-Washer.—This is an exceedingly ingenious and simple root-washer, and does equally well for seed, corn, Egyptian beans, &c., when provided with a perforated cylinder. Fig. 43 represents this machine; it consists of a cylinder similarly constructed to the one we have described by Richmond. In this cylinder is placed a spiral chamber, against which the roots press while being washed, which is done by a winch turning the cylinder in a water tank; when the roots are cleansed the motion of the cylinder is reversed, and the roots pass through the spiral into a shoot, as shown in the woodcut.

The two legs at one end of the cistern are placed upon wheels, and at the other are two barrow-handles, thus

enabling the machine to be removed from place to place with extreme ease.

Fig. 43.



CROSKILL'S ARCHIMEDEAN ROOT-WASHER.

APPARATUS FOR COOKING FOOD FOR STOCK.

The advantages of cooking the food of animals are so well understood now, that a steaming apparatus is considered indispensable to every well-ordered steading. The process of boiling or steaming is known to effect great and important changes, both in the chemical and mechanical condition of food, and to render many substances suitable for the digestion of animals which, in their raw state, are indigestible or unwholesome. The mechanical division of boiled food facilitates the acts of mastication, swallowing, and ruminating (in ruminating animals).

Hence it naturally results that cooked food is more economical, as digestion being more perfectly performed a less quantity of food will suffice to produce the increase of

weight in the animal. The boiling of the food of animals is one of the best known means of promoting digestion; it also increases the quantity as well as the quality of the alimentary substances which undergo the process. This advantageous result appears to originate in part from the circumstance that the molecules of the alimentary substance are separated by the coction which they undergo, and thus present a greater surface to the influence of the gastric juice, and partly from the influence of the water in which they are immersed, as well as the high temperature to which they are exposed, augmenting their nutritive powers. The water seems actually to become solid, as in the making of bread, by entering into union with them, or by imparting its hydrogen, which afterwards, uniting with carbon, contributes greatly to the formation of fat.

The ordinary apparatus used for steaming food for stock, consists of a copper or boiler for generating the steam, and a receptacle into which the food is placed to be acted upon by the steam.

The boiler is made in a variety of ways, it being only necessary to construct it of sufficient strength to bear a pressure of about two pounds to the square inch. Sometimes the boilers are made spherical, at others cylindrical, and often a small waggon-shaped boiler is used. In steadings of large size, where a fixed engine is used, the boiler employed to generate the steam for the engine, should also supply the coppers for cooking the food. In small farmeries a complete apparatus for steaming may be purchased adapted to the size of the holding. Several of these are now manufactured by different houses, properly constructed for the purpose. Among these, Stanley's seems to be considered one of the most complete: it consists of a portable steam-generator, a strong oak compound tub, with copper or iron inside lining, and a six-bushel vegetable-pan. It is fitted complete, with force-pump, water-gauge, unions, and pipes.

The vegetable-pan is a cylinder, supported in the centre on each side. Through one of these bearing-trunnions the steam is admitted. This manner of hanging is to enable the pan to be tilted, so as to discharge its contents into the pails or barrows, in which it is carried to the stock.

A neat and convenient apparatus is manufactured by R. Robinson, of Belfast; the boiler being a cylinder standing on four short legs; in this cylinder is placed the furnace, and above it a vase-shaped vessel for supplying water. The vegetable-tub is placed on a barrow, so that it can be removed straight to the stock after the food has been cooked. This machine is well adapted for cooking out of doors, as the whole apparatus may be removed from one place to another with great facility. Messrs. Richmond, of Salford, received a medal at the Derby Meeting of the Royal Agricultural Society, in 1843, for a very complete steaming apparatus, particularly recommended for its fittings, as regards safety, supply of water, &c.

A variety of plans are in use for steaming and cooking food, but the kind of apparatus we have described, as made by Stanley, Richmond, and others, is so superior to all others, that it is not worth while describing them.

CHAPTER XI.

CHURNS AND THE UTENSILS OF THE DAIRY.

The Churn is a machine for agitating milk and cream, by which means the butyraceous matter is separated, and butter produced.

The simplest and oldest form in which churns are made is in the form called the conical cottage dash-churn. This is constructed by the cooper, and consists of a long narrow

tub, tapering upwards to allow of tightening by hoops; it has a lid, and in that a small central aperture, through which works a staff or handle; on the bottom of this, inside the cylinder, is a round disc of wood, with a number of holes cut in it, or else it is made of separate bars. The diameter of the disc is something less than the upper diameter of the cylinder.

The simple motion perpendicularly of the handle upwards and downwards works the piston, or perforated board, at the bottom, through the cream, and agitates it sufficiently to cause it to throw up the butter in lumps. It is taken from the churn in this state, and made up to lumps for market, or placed in casks with salt. This description consumes considerable power when worked by hand, and is slow and tedious.

In large dairies, the churn employed is usually a barrel (not bulged in the middle), having in one end a hole, through which the cream is admitted, and the butter extracted. Over this hole is a plate of metal or wood, which can be screwed down to the head of the barrel,—a piece of leather or cloth being first placed between the parts, in the centre of each head of the barrel are securely and accurately fixed two gudgeons or spindles. These are placed in proper bearings set upon a strong frame, and on one end of the gudgeons, or both, are placed winches, by which the barrel may be made to revolve. In the interior of it, parallel with its axis, and secured to it, are pieces of board radiating from its centre. These agitate the milk sufficiently, as the barrel is turned.

The chief defects of this machine are a too great tendency to carry the milk round with the barrel, and the difficulty of getting at the interior to properly cleanse it after churning.

Another barrel-churn is made by causing the barrel to remain stationary, and placing a shaft through its centre, upon which the dashers are placed. The operation is much

the same, except that in the one case the milk is worked against the dashers, while in the other the dasher is worked against the milk.

Box-churns are similar in their action to the one just described, except that they are four-sided, while the other is cylindrical. These are made in immense variety, the difference of the shape of the dasher being the chief cause of the variety.

The ordinary old box-churn dasher consisted of eight arms fixed upon a spindle, four on each side of the box, the arms radiating from the centre, and placed at right angles to each other; between these arms are placed narrow flat pieces of wood, generally three in number (in the small hand-churns), the spaces between them and their width being equally divided. The spindle passes through the centre of these arms, and gives motion to them by means of a winch-handle outside. One end of the spindle works in a bush let into one side of the box, and the other nicely secured from leakage by means of a plate secured to the top of it; the bearings of the spindle are generally made of ivory, as brass bearings would taint the cream. Churns of this description are made of all sizes, suitable to the extent of the dairy for which they are intended. A churn has been introduced in Ireland, and considered as a great improvement upon this. It consists in placing round the lower part of the box a water space (the box being made of metal in the lower part, and semicircular in form); the ends are of the ordinary woods, as birch or palm-tree. The water in this outer case of the churn is employed to regulate the temperature of the cream. It is supplied to the reservoir by means of a funnel, and a tube passing down the side of the upper part of the box; it is covered with a lid like the ordinary box-churn. One peculiarity of this machine is that the spindle passes through this in the direction of its greatest dimension, while in the others it is through its

shortest. The regulating-bars are here round rods instead of flat spars. The whole is mounted on a metal frame, and has a compact and handsome appearance. An exceedingly elegant and good churn is described in Stevens's "Book of the Farm," as being originally invented by the justly celebrated Mr. Wedgwood, though lately brought forward as a new invention.

This containing vessel is still formed of the Wedgwood stone-ware of the strongest white glazed kind, and has a varnished wooden cover; the outer case is made of sheet zinc: both inner and outer cases are cylindrical, and an ample space is left between the two. In the inner cylinder is placed a vertical spindle, upon which the dashers are placed; these are three vanes of wood or metal nearly the whole depth of the churn, and having perforations through them; on the top of the spindle is sometimes placed a horizontal wharve or pulley, and the machine is put in motion by means of a bow-string. This is effected in the same manner as a watchmaker works his drill, the bow being bent until the string is sufficiently slack to enable it to pass once round the pulley; the bag is then allowed to expand outwards, and being then pulled backwards and forwards, gives a motion of considerable velocity to the spindle. This motion being reversed, is highly favourable to the producing the butter.

As a substitute for the bow-string (which is not the most easily managed means for giving motion, unless for exceedingly small machines), there is placed on the top of the spindle a mitre-wheel or pinion, and supported by an iron frame; on a cross-shaft is another larger mitre-wheel which receives motion from a crank or winch, the motion being reversed every second revolution.

Mr. Stevens gives the following result of an experiment made to ascertain whether the alternate motion might not be dispensed with:—

"In the plane cylindrical vessel, with the agitator always moving in one direction, butter was obtained in fifty-five minutes. In the same vessel, with the agitator moving alternately right and left, at every two revolutions, butter was obtained in twenty-five minutes.

"In this same vessel, fitted as above described, with counter agitators, but with the agitator moving in one direction only, butter was obtained in twenty minutes. From these results it appears that, even with a cylindrical vessel, if properly armed, the process is performed in a shorter time than with inconvenient reversed motions."

A peculiar churn is noticed in Lambert's "Travels in the United States and Lower Canada:"—

"At a farmer's near Lake Champlain, we saw a machine for churning butter. It was a kind of half-barrel, with a place where one of the farmer's sons sat astride as on horseback. The machine, moving up and down, answered the double purpose of a rocking-horse for his children, and a machine for making butter."

The Lancashire churn is considered to be a good one, and is worked with a cord similarly to the bow-string churn; but in this case no bow is used, a triangular frame of wood being substituted in its place; one angle works in a gudgeon on the ground beside the churn, the other two angles have secured to them the cord which passes round the top of the staff, there being no pulley as in the other. The operator stands with one foot on each side of the triangular frame, and throws his whole weight alternately from one side to the other; the cord is thus made to wind up the dasher as well as turn it round, thereby producing a compound motion, combining both the action of the box-churn and the old vertical acting dash-churn.

The Derbyshire churn is a combination of the barrel and box-churn, the dasher working similar to that in the box-churn, but is composed of flat boards with holes through them.

A great deal has been said of late about American churns, and the great improvements effected in them; they are of two kinds, Antony's Cellular Agitator or Dasher, and Dalphin's, with a curved moveable piece attached to a cellular dasher.

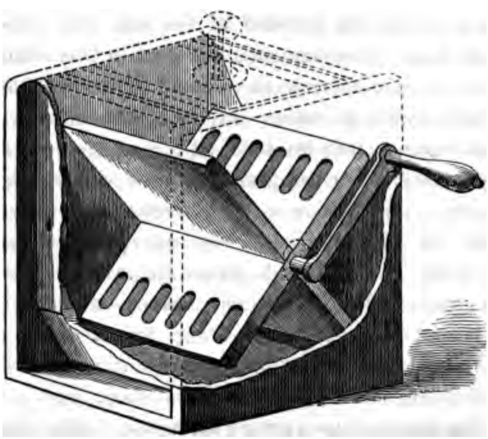
In Antony's churn the dasher is a flat board, having a piece of wood running all round the edge of it, and projecting about an inch above it; between these raised sides are cross pieces, four in number, of the same height as the rim-pieces, thus dividing each side of the dasher into five divisions or cells, the middle one being considerably the largest. The advantage of having these cells is to carry down into the cream a quantity of air, and the cross-pieces produce a better agitation than the ordinary bars of the box-churn.

Dalphin's churn is also a cellular churn, the backs of the cells being curved instead of square, as in Antony's; but the principal difference is the having a moveable piece turning on a centre at each side of the dasher. It is said to offer a peculiar resistance when the butter is first forming, which greatly facilitates and increases its production when turning; the cream is agitated by meeting with the slats of the dasher, which are set at such angles as to force the cream towards the centre; it is then met by the moveable floats, which when revolving stand open, and cause the cream to move outwards, which various and contrary motions so agitate it, that the butter is soon produced. The proprietors of this churn say, that without removing the butter, and with the same motion, it will perfectly separate every particle of buttermilk from the butter, wash it in clean cold water, work in the salt evenly, and turn it out a solid mass of pure butter. The arrangement of the dasher is such as to allow of its being turned with great ease, and bring the butter in a very short time; reversing the handle, that is turning in the opposite direction,

causes it to gather the butter and work out every drop of buttermilk.

In very large dairies it is necessary to have churns of large size, to be driven by horse-gear, water-wheels, or steam power. All the churns we have described may be constructed of large dimensions, but the arrangements for giving motion to the dashers become then a matter of importance. Messrs. Richmond & Chandler have produced a churn for large dairies that is I think the best I have ever seen; its superiority consists in having a double perpendicular action, by which the plunger of the downward stroke forces the cream through the middle partition, following the upward plunger, so that at the reversion of the cranks, the cream is met by the plungers and forced backward and forward in rapid succession, "crasing" and agitating it in a few minutes into small particles of butter; after which, by slowly turning the crank, the small particles adhering to each other quickly become in a condition to be taken out.

Fig. 44.



Tytherleigh's patent barrel-churn is considered a most excellent one; it is in use in her Majesty's dairy at Windsor, and has given the greatest satisfaction.

Curd-Breaker.—This machine is used for breaking the curd in the manufacture of skim milk, cheeses, &c. It consists of a hopper of wood 17½ inches by 14 inches on the top, and 10 inches in depth, and a cylinder of hard wood 6¾ inches in length, and 3½ inches and a half in diameter. The cylinder is studded with square pegs made of hard wood, each a quarter of an inch in the side, cut square at the ends, and projecting three eighths of an inch. There are eight teeth in the length, and fifteen in the circumference of the cylinder, 120 teeth in all. It revolves on a round iron axle 12 inches in length, and is moved by a crank handle; there are two wedge-shaped pieces of hard wood, made to fill up, in some degree, the space between the side of the hopper and the cylinder. These pieces rest on a slip of wood nailed to the lower rim of the hopper, to keep them in their place. The face of these is studded with nine teeth of hard wood, similar to those on the cylinder, at opposite sides. The stand can be made of any length, to suit the breadth of the tub into which the curd is broken. The implement is used in this manner:—Place over it a tub, heap the hopper with curd, and, on turning the winch in either direction, the curd will fall, broken quite small, into the tub. While one hand is moving the machine, the other can press the curd gently down into the hopper. As cleanliness is a matter of the greatest importance in cheese-making, the internal parts of this machine, being loosely put together, can be easily taken to pieces to clean. The cylinder axle rests on two hard wooden blocks, one on each side, which slip out of their groove. They are held in their working position by the thumb-catch sunk flush with the bottom of the stand, one over each block. The wedge-shaped pieces come out. To prevent the

curd working out of the sides of the axle, the cylinder is set a little at both ends into the sides of the hopper.

Cheese-Presses.—A variety of contrivances are used for this purpose, but they are all similar in their action, the object being to place a heavy weight on the forms of curd, which weight shall descend regularly down after the cheeses as they decrease in bulk, from the whey being expressed from them. The old form of cheese-press was usually a heavy weight of stones placed in a box, which was raised either with a screw, or cords and pulleys. The more modern cheese-presses act by the action of levers instead of weights, or by pneumatic pressure. Baird's press is one of the best in common use, and is described in the Highland Society's Transactions. It consists of a circular bed-plate, supported on four curved legs; from each side of this bed-plate, two circular iron columns are fixed to support a cross piece, through which passes a bar of iron, one side being formed into a toothed face or rack. On the lower end of this bar is placed another circular plate having two ears, one on each side, with holes in them, through which the two perpendicular rods before mentioned pass; this second plate corresponds with the former one in size, and it is between them that the cheeses are pressed. On the cross piece is placed a pinion which acts against the rack; a lever is placed in such a manner as to act upon the pinion according to the force employed, by placing a weight upon the lever at suitable distances from its fulcrum. Cheese-presses upon this principle are made by a variety of manufacturers.

An improvement upon this press has been made by Thewlis & Griffiths. In theirs, the facility for making and pressing cheese is secured by means of a pair of bevil wheels, and a treble pitch screw, regulated by a self-acting lever and weight, whereby a pressure of upwards of two tons may be obtained.

Robinson's Pneumatic Cheese-Press is thus described in

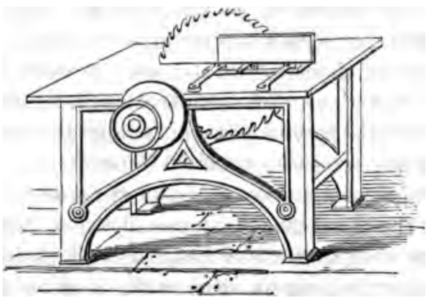
the Highland Society's Transactions. When of full size, this press may consist of a stand about three feet high, on the top of which may be fixed a tinned copper or zinc vessel of any required capacity (say 18 inches diameter, and 18 inches deep) to contain the prepared curd. This vessel should have a loose bottom of ribbed work, covered with wire-cloth, from under which a small tube nearly twelve inches long, should communicate with a close vessel, capable of containing all the whey which may be drawn from the curd in the upper vessel. At one side of the stand there may be a small pump-barrel of about seven inches deep, from the bottom of which a suction pipe should terminate at its upper end in a valve opening upwards, and a piston with a similar valve should be placed in the pump-barrel, and be worked by a jointed lever. The process is to be conducted as follows:—The curd being prepared, and salted in the usual way, a cloth is to be put over and into the upper vessel, and the curd put lightly into it, except round the edges, where it should be packed quite close to the sides of the vessel, so that no air may pass that way; the pump handle is then to be briskly worked for a few minutes, on which the pressure of the external air will force the whey to run down the tube into the whey-vessel; when it ceases to run, a few strokes of the pump may be repeated. The cloth and its contents are then to be lifted bodily out of the curd vessel, and to be put into a mould of close wirework, with a weight placed over it until it become firm enough to be handled. The mould should stand on a sparred shelf (a shelf made of laths like a bacon-rack) to allow the air free access to it on all sides of the cheeses.

CHAPTER XII.

CIRCULAR-SAW BENCH.

THIS machine is indispensable to every large farm;—sawing being a most expensive description of labour when performed by the regular sawyer; and the large quantity of sawing required to be done on a large farm renders the fitting up of a saw-bench a positive economy, as the motive power of the steading may be employed to drive it; and fencing, as well as nearly every other description of sawing, may be performed with it, and at a comparatively trifling cost.

Fig. 45.



CIRCULAR-SAW BENCH.

Fig. 45 represents a small saw-bench, adapted to farm purposes, the framing being entirely of iron. They are generally made of wood; and if the steading is being built new, and the timber-work constructed of the timber grown on the estate, as is often the case, the bench had better be of wood. It is constructed in the following manner:—An exceeding strong wooden framing is prepared, about 8 feet

long, and 4 feet wide, and about 3 feet 6 inches from the ground. The timber must be of great strength, and very securely framed by tenon and mortising, and strong iron bolts passing from side to side, tightening up against countersunk iron plates. The framing must be supported by diagonal pieces tenoned into the centre of the upper rail, and into the posts and lower rail. These diagonal pieces are sometimes omitted, but when they are, the bench will be sure to become rickety, as it is impossible to construct frames of machines, that have to resist great strains, like a table on four simple legs. Near the centre of the table, in the direction of its length, is placed and sunk, so that its upper surface may be exactly level with the surface of the table, an iron plate. In this plate is a cut or slot, or half the iron lengthways is moveable. Under the bed-plate, crossways of the table, is placed a strong iron shaft or spindle, supported on two plummer blocks. On one end of this spindle are two pulleys, the one fixed to the spindle, and the other running loose upon it. At the other end of the spindle is a disc of iron, having a perfectly flat face; a small piece of the spindle projects through the centre of this iron plate, and upon that is placed the saw.

The saws are flat circular plates of steel, having teeth cut upon their outer edge. They are made of various sizes, from 10 inches diameter to 4 feet, the teeth being cut large, and shaped for ripping up large stuff, or small for cutting joiners' wood.

The saw has a hole in the centre exactly the size of the turned end of the spindle upon which it is placed, and another disc of iron is screwed upon it, pressing it and holding it securely against the other, and in its place, so as to run perfectly true. The moveable portion of the bed-plate is then replaced, and rather less than half the saw appears above the surface of the table. A strap from some portion of the machinery in motion is placed upon the loose

pulley on the spindle when the saw is required to be used; the strap is pressed towards the fixed pulley, which, from its shape, immediately runs upon and gives motion to the saw. It is necessary that the saw should revolve with immense rapidity, or it will not be effective.

To enable the sawyer to use this saw when so revolving, it is necessary that some means must be contrived to enable him to secure the piece of wood he is cutting from moving out of a straight line while the saw is passing through it. This is effected by a guide-plate of wood or iron, placed exactly parallel with the line of the saw. At the back of this is another plate, also perfectly parallel, and from one to the other extend bars of iron, moveable at the points, where they are held exactly the same as an ordinary parallel ruler. The guide-plates may by this means be brought close up to the saw, or removed ever so far back towards the points. In the wood-cut there is no plate at the back, the radius bars being fixed to the table, the guide-plate being set to any fixed distance from the line of the saw, and secured by screws in that position. The piece of wood to be cut is placed upon the table, and moved against the cutting-edge of the saw, while at the same time it is pressed firmly against the guide-plate. Being kept in this position while gently moved forward, the saw will, of course, pass through it in a perfectly straight line, cutting off a piece of exactly a thickness equal to the space between the guide-plate and the saw.

CHAPTER XIII.

VERMIN, AND THE METHOD OF DESTROYING IT.

Of vermin that infect the steading, the rat is by far the worst, and the most common.

The rat usually met with is the domestic rat of Norway, or gray rat, which has almost entirely extirpated the indigenous black rat. To get rid of him is an exceedingly troublesome affair. The best way is to prevent his coming, or rather taking up his abode; and this may be done by constructing the building in the manner described in Vol. I., so as to prevent, as much as possible, his travelling about on the top of the walls, and under the floors. An immense variety of plans are resorted to to catch and kill these animals: by poison laid about for them to eat, by traps set at different places, or by a rattery regularly constructed in some particular situation, and by employing animals, as dogs and cats, to catch them.

Of the different plans, the following appear to me to be the best:—Fry a piece of sponge or cork in butter; then compress it between two plates; afterwards cut it in little pieces, and lay it about for the vermin near the holes they frequent. They will eat it with avidity; and as it excites excessive thirst, they will drink water, which immediately swells the fried sponge, and kills them.

Plaster of Paris, mixed with barley-meal and salt, is said to produce a similar effect.

Rubbing their holes with Stockholm tar soils their coats, and puts them to such inconvenience, that they will leave the place. Mixing barytes with water produces such intense thirst, that they will seek water immediately, and die the

moment they drink. Poisoning their food with arsenic, and mixing treacle and arsenic together, and smearing their holes with it, is found to be effective.

A variety of other poisons are used; but they are all dangerous to the other animals about the steading, and had better not be used if possible.

Rat-traps are made in great variety; but these soon acquire the disagreeable odour peculiar to rats and mice; and after that is the case they will not enter them.

The best plan is to have good cats, well kept; for they will be more effective in clearing vermin when in good condition than when half starved. They should be regularly fed every day, like any other animal; and they will keep the interior of the buildings clearer of both rats and mice than any traps or poisons could effect.

CHAPTER XIV.

SCIENTIFIC INSTRUMENTS.

The class of persons into whose hands the farm lands of this country will soon pass will possess such a superior amount of intelligence that the most scientific operations will be accurately performed, and all the benefits of a scientific knowledge rendered available.

The use to any extent of philosophical instruments by the old class of agriculturists was out of the question; but there is no reason now why those who have the management of large and valuable farms should not be as well able to use a scientific instrument as those who have the management of large merchant ships, as there is no doubt but the agriculturist may derive considerable advantage, and his judgment be *materially* assisted, by the use of them.

It is well known that the weather effects a sensible power in retarding or accelerating field operations. It is therefore positively incumbent on the master of a farm to make himself as thoroughly acquainted as he can with the principles which regulate the phenomena of the atmosphere, so as to enable him to form as correct a judgment as possible of what weather to expect when about commencing any particular operation. To aid him in this, he will require the following instruments :—A barometer, thermometer, hygrometer, rain-gauge, and a weathercock, fixed in some position where it may be easily observed, and not affected by local currents and eddies of wind.

The barometer is an instrument for determining the weight of the air, and the variation of its pressure under different circumstances. It was invented by Evangelista Torricelli, a pupil of Galileo, whom he succeeded as teacher of mathematics at Florence. He calculated that the same cause which raises water 33 or 34 feet high (a fact which Galileo had previously discovered) should raise mercury, which is fourteen times heavier, only 29 or 30 inches; and his experiments proved the correctness of his theory, that the column of mercury was supported by the pressure of a column of air resting on the mercury in the tube, and extending upwards to the limit of the atmosphere.

Torricelli, in constructing his first barometer, closed a tube of glass hermetically at one end, then filled it with mercury through the other; and upon inverting it in a vessel containing the same material, he found the mercury descend in the tube, and remain 29 or 30 inches high. The space in the upper part of the tube unoccupied is called the Torricellian vacuum.

Barometers adapted for judging of the weather are made in a variety of forms; but the two in general use are either an upright column of mercury, with a graduated scale, or what is called a wheel barometer, which has a face, with

hands pointing to a graduated circle, and marked rain, fair, &c. The latter plan, though most commonly used, is not so good as the upright tube, as there is considerable machinery to be put in motion by the mercury, to indicate the change on the circular face; this must naturally lessen the delicacy of the indication.

The tube of the barometer is a most important matter. It should be perfectly true and cylindrical, about 33 inches in length, and the bore must not be too small, which it in nearly all cases is, to save mercury; for when it is so, the friction and capillary attraction will affect the free motion of the mercury up and down the tube.

The mercury should be carefully freed from all foreign metals. Common mercury is greatly adulterated with tin, lead, and bismuth.

In observing the mercury, if the upper surface in the tube is convex, it is about to rise; if concave, to fall. The scale is usually graduated to the level of the sea; that is, the mercury rises the lower it descends towards that level, and falls as it is removed to greater altitudes. Should a farmer possess an instrument so graduated, and he reside up in some hill country, the mercury would not indicate truly according to the figures and writing on the scale. It is therefore important to register the actual fall and rise of mercury, and judge by that more particularly.

The indications of the barometer are thus:—When the mercury is high and remains so, good weather; a gradual and equal fall is indicative of rain, and the more rain if the wind is east of south. Sudden changes of the level of the mercury indicate similar change of the weather; and sudden falling of the mercury to any extent surely indicates gales of wind and storms. We have not space in this little book to point out all the various peculiarities of the instrument, and the changes it is liable to. The observer should study *some scientific* work which treats of the subject at length.

The thermometer is an instrument for measuring heat, on the principle that the expansion of matter is equal to its augmentations of temperature. A variety of materials have been used in the construction of thermometers—water, alcohol, and oil,—but mercury approaches more nearly to solids in its rate of expansion, and remains liquid through a longer range of temperature; it is, therefore, adopted as preferable to all others. A common thermometer is merely an instrument in which very minute expansions of the mercury are rendered perceptible. This is effected by filling a glass tube with mercury, in a similar manner to what we have described for the barometer, and attaching to it a graduated scale. Common thermometers are exceedingly inaccurate, in consequence of the irregularities of the inside of the tube. The scale, which is placed by the side of the tube, should be graduated, to allow for the inequalities, if for any very minute purpose; but as no very accurate observation is required by the agriculturist, an ordinarily constructed one will be sufficient. They are exceedingly cheap; and all cattle-feeding houses should be provided with one, and an equal temperature be preserved.

CHAPTER XV.

THE RICK-YARD.

In the rick-yard will be required to be placed frames, or beds of some kind, upon which the stacks are to be placed, and so constructed that vermin be not able to get at the grain, which it will most assuredly do, if no means be taken to prevent it. Sometimes a circular wall is built, with a projecting coping; but the usual plan is to construct stack-stools or staddles. This is done by arranging as supports, at

distances according to the size of the rick, a series of stone or iron pedestals, conical in shape, and having on the top a cap of the same material, but of considerably larger diameter, called the bonnet,—the outer edge of this cap stone being so far removed from the upright piece, prevents the possibility of vermin being able to mount to the frame that supports the stack.

These staddles are now made of iron by all the implement manufacturers, at a reasonable price; and are by far the best things for the purpose. An excellent description is made by Messrs. Garrett, of a circular form, and of three rings, one within the other. The supports are small wrought iron columns, resting on square bases, and surmounted with hollow conical caps. It is impossible for vermin to reach the rick when it is thus protected; and a free current of air being secured through, the corn is hardened and dried better than by any other plan.

Deane, Dray, & Co., make an excellent rick-stand, square, upon cast-iron legs, with conical caps, and supporting a square frame.

The rick-yard should be enclosed with a good wall, and be trimmed to an even surface. For the plan of arranging the ricks, the reader is referred to Vol. I., p. 82. A rail or tramway should be laid down, for facilitating the removal of the ricks to the thrashing-barn, and the removal of straw back to the rick-yard, should it be thought necessary to restack it, after having passed through the machine, as is often done. For the manner of constructing the railway, see article on farm railways, in Vol. III. of this work.

The Rick-yard Truck.—A variety of contrivances have been made for removing the straw in the rick-yard; sometimes the stacks have been constructed on staddles which had wheels, and the whole rick was to be bodily moved up to the thrashing barn, but this is an exceedingly difficult plan to carry out, and would take up a great deal of room, and require a great

length of railway to be laid down. That there must be a railway is agreed on all hands, and the only difficulty is, that the stacks must be arranged on either side of a straight line of rails, which would be impossible in many cases, and exceedingly inconvenient in others, or, a considerable expense must be incurred in having turntables at each junction of cross line, so as to get at the ricks from the main line; now as these turntables would be very expensive in the first cost, and would only be used perhaps twice a year each, it is evident that the increased cost of carrying the ricks by the ordinary means of carts and waggons would be preferable to allowing a large sum to lie idle in the shape of turntables, only to be used once or twice in a year; some means must therefore be devised to keep the lines crossing each other at right angles, and get rid of the cost of turntables. This has been done in two ways; first by Mr. Morton in the following manner.

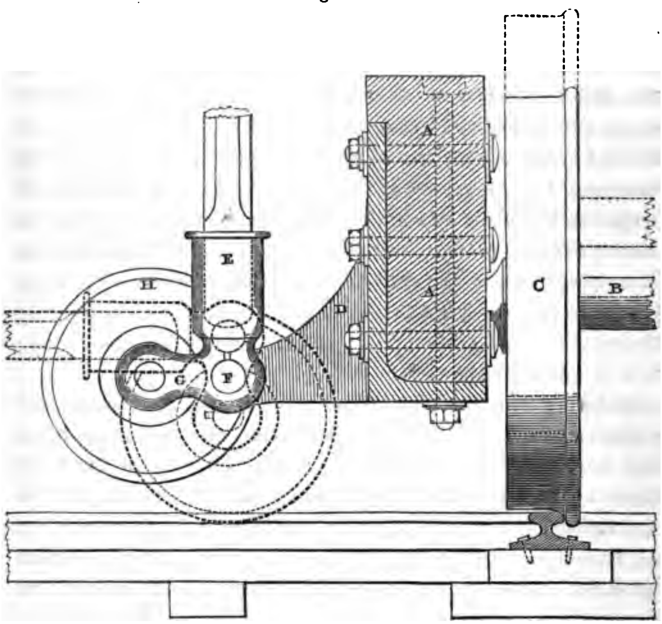
Between the principal lines of ricks is a sunk road with a line of rails upon it, and upon this is placed a truck; upon this truck is placed crossways, a pair of rails, fitting with those on the cross lines; a truck being laden at the side of the rick on the cross line, it is run along till its wheels are on the cross rails of the truck on the main line, and which we before stated is in a sunk road. The truck laden from the cross line, upon the truck on the sunk line, are then together run up to the thrashing-barn. There is no doubt but this plan answers very well, its objection only being the expense of two trucks instead of one, and the cost of making the channel in which the sunk truck runs. I question whether much is saved from the cost of turntables.

The other plan is one I have myself invented, and which I think gets over the whole difficulty. It is by having a truck so constructed, that it will pass from one line to the other without the aid of a turntable.

Fig. 46 represents a portion of this truck, showing the

manner in which the wheels are arranged to work on both lines: A is the side frame of the truck, B the axle, upon which is placed the wheel, C an ordinary flanged railway

Fig. 46.



wheel; there would of course be four of these wheels on two axles, as in any ordinary four-wheeled truck; beside the frame outside is placed a cast-iron carriage D; in this carriage works the foot of a moveable lever E, upon a pin F, through cheeks; at the bottom of the lever is a projecting piece G, at right angles with it; at the end of this is placed a small wheel with a flange H. When the lever E is in an upright position, the bottom of the wheel at its outer end is about an inch above the level of the rails on the main line, *upon which* the flanged wheels C are running. When it is

required that the truck shall be used on the cross line, the wheels H, of which there are of course four, are brought over the cross line, and the lever E being turned down and secured by a ball, the other wheels C, which are on the main line, are lifted up an inch from the rails, and the truck then proceeds along the cross line for its load upon the four smaller wheels now brought into action; on its return to the main line, they are raised again by the lever, and the other wheels descend upon the main line of rails, and the truck moves in a direction at right angles with the one it had just left. The dotted lines show the position of the wheels when moving on the cross line, and the full lines the position when working on the main line. The truck of course moves end foremost on the main line, and sideways on the cross line.

PUMPS

should be provided for lifting and forcing both water and liquid manure, as it is essential that all the animals, and the different departments of the steading should be supplied with water, without the trouble of horsekeepers' and cattlemen having to fetch it from a distance.

A head of water should be placed in some convenient position in the steading, so that it may, by its own gravity, descend to all the various troughs, cisterns, and other receptacles.

The tank or head should be kept filled by a force-pump attached to the engine.

Liquid Manure Pumps are usually common lift-pumps of cast-iron (and often galvanised to prevent the rapid corrosion consequent upon their situation). Lift-pumps are employed because the tanks are only a few feet deep, and the pump is only employed to lift the liquid to the carts, and is worked by hand; but a different system of supplying liquid manure to the land is now coming into use, which

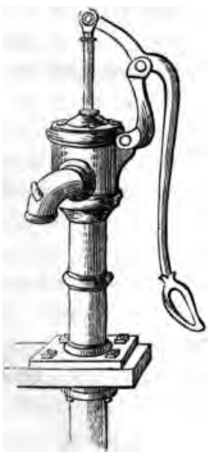
will require quite a different arrangement and kind of pump. The practice alluded to has been introduced by Mr. Huxtable, of Sutton Waldron, and is now also adopted by Mr. Mechi, at his farm at Tiptree Hall, Essex; it consists in laying down a regular main from the homestall to the lands and by a force-pump driving the liquid manure through it to the distant parts of the farm. Mr. Huxtable remarks that hitherto the expense of cartage has been an effectual impediment to the application of the contents of our tanks, except to a few fields around the homestead; and therefore there has been no systematic delivery of the precious fluid over all the farm. The method he first adopted was to lay down wooden pipes, carefully jointed; but experience afterwards showed that well burnt clay pipes, one inch thick and carefully jointed, would stand a pressure of 200 feet head, without the liquid oozing through the pipes or joints. The pipes were $1\frac{7}{8}$ inch in diameter, and cost *7d.* per yard; they are placed 2 feet underground, and at every 200 yards is inserted an upright column, bored to the same gauge as the pipes themselves; on the top of these is placed a spout for the delivery of the liquid. Mr. Huxtable's neighbours have some of them adopted the plan, and as Mr. Mechi has had an opportunity of ascertaining how it works, for some considerable period, and has now adopted it on his own farm, we may conclude that the plan having been fairly tried and found to answer well, will be generally adopted by the agriculturists of this country. If this is the case, fixed and larger engines will be employed on the steadings, as the labour of driving the liquid manure through the pipes to all the various parts of the farm should be done by steam-power; and a larger amount of other manures will be employed, as dissolved bones, guano liquid, or any other manure dissolved in water, may be forced through the main equally as well as the drainings from the cattle-stalls. In *part I. p. 43,* of this work, will be found a plan of a

horizontal steam-engine, and a force-pump alongside to be brought into use whenever necessary.

By an easy contrivance the pump may be made to draw from the receptacle of the liquid manure, and force it over the land: or the same pump may be made to draw from the well, and supply the cistern or head of water for the use of the farmery, as separate pipes would of course be prepared for liquid manure and water, and only the pump, barrel, and plunger work both; but these would in a few strokes quite clean themselves, and no inconvenience result from such an arrangement.

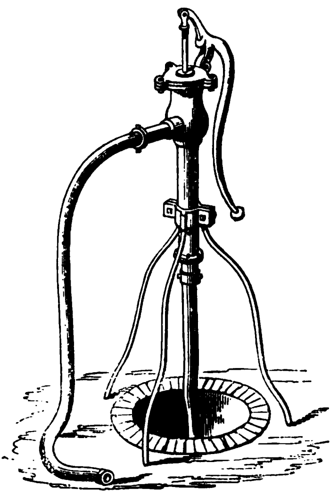
Steam power is so exceedingly economical when compared

Fig. 47.



LIFT-PUMP.

Fig. 48.



LIQUID MANURE-PUMP.

with the labour of either men or horses, that I apprehend the greatest possible benefit will arise from arrangements that throw the labour of either the one or the other upon

it; and the more this is done the larger power will the engine require to be; and the larger the engine the more economical will be its working, and, consequently, increased saving to the owner.

When a head of water is placed for the supply of the steading, an arrangement should be made to turn it to account in case of fire; and this may easily be done by having a coil of hose and a branch placed in some convenient situation, and cocks placed upon the pipes that supply the buildings. The situation of the cistern would of course not be placed higher than necessary, as it would entail useless labour in pumping; the force-pump, therefore, should be so arranged that it could be brought into use in the event of fire, and when worked by the steam engine would be so effective as to speedily get under any conflagration.

A steam-cock might be placed in the rick-yard, in such a situation as when a hose was attached any rick might be got at, should a fire be discovered in that portion of the premises.

END OF VOL. II.

BRADBURY AND EVANS, PRINTERS, WHITEFRIARS.

32. Rudimentary Art of Use of Instruments (generally), by J. F. Heather, M.A., of the Royal Mil. Acad., Woolwich, 2nd edit. . 1s.
33. ———— Constructing Cranes for the Erection of Buildings and for Hoisting Goods, by J. Glynn, F.R.S., C.E. . . 1s.
34. ———— Treatise on the Steam Engine, by Dr. Lardner. (*Written specially for this Rudimentary Series.*) . . . . 1s.
35. ———— Art of Blasting Rocks and Quarrying, and on Stone, by Lieut.-Gen. Sir John Burgoyne, K.C.B., R.E., &c. &c. . 1s.
36. ———— Dictionary of Terms used by Architects, Builders, Civil and Mechanical Engineers, Surveyors, Artists, Ship-builders, &c. vol. i. . . . . 1s.
37. ———— vol. ii. . . . . 1s.
38. ———— vol. iii. . . . . 1s.
39. ———— vol. iv. . . . . 1s.
40. ———— Art of Painting on Glass, or Glass-Staining, by Dr. M. A. Gessert, with an Appendix on the Art of Enamelling, &c. 1s.
41. ———— Essay on the Art of Painting on Glass, by E. O. Fromberg 1s.
42. ———— Treatise on Cottage Building; and some new Hints for Improving Dwellings, by C. B. Allen, Architect . . . 1s.
43. ———— Tubular, Girder Bridges, and others, more particularly describing the Britannia and Conway Bridges, with the Experiments made to determine their form, strength, and efficiency, by G. D. Dempsey, C.E. . . 1s.
44. ———— Foundations and Concrete Works, by E. Dobson, C.E. . . . . 1s.
45. ———— Limes, Cements, Mortars, Concrete, Mastics, Plastering, &c., by Geo. R. Burnell, C.E. . . . 1s.
46. ———— the Art of Constructing and Repairing Common Roads, by H. Law, C.E. . . . . 1s.
47. ———— the History, Construction, and Illumination of Lighthouses, by Alan Stevenson, LL.B., F.R.S.E., M. Inst. C.E. . . . . vol. i. 1s.
48. ———— Ditto, Continuation of the same subject, vol. ii. 1s.
49. ———— vol. iii. 1s.
50. ———— the Law of Contracts for Works and Services, by David Gibbons, Esq. . . . . 1s.
51. ———— Naval Architecture, the Elementary Principles of the Science, by J. Peake, H. M. Naval Architect . . 1s.
52. ———— the Practical Principles of Ditto, forming a 2nd and a 3rd volume, to complete the work, vol. i. . . 1s.
53. ———— vol. ii. . . 1s.
54. ———— Masting, Mast-making, and Rigging of Ships . 1s.
55. ———— Navigation: the Sailor's Sea-Book; in two Parts: I. How to keep the log and work it off. II. On finding the latitude and longitude. By James Greenwood, Esq., B.A.—With Directions for Great Circle Sailing; an Essay on the Law of Storms and Variable Winds; and an Explanation of Terms used in Ship-Building, with coloured illustrations of Flags, vol. i. . 1s.

56. Rudimentary Treatise on Navigation, &c., vol. ii. . . . . . . 1s.
57. ———————— the Principles of the Art of Warming and Ventilating Domestic and Public Buildings, Mines, Lighthouses, Ships, &c., by Chas. Tomlinson, vol. i. . . 1s.
58. ———————— vol. ii. . . 1s.
59. ———————— Steam Boilers, their Construction and Practical Management, by Robert Armstrong, C.E. . . . 1s.
60. ———————— Land and Engineering Surveying, for the use of Schools and Private Students; for Practical Land Surveyors, and Engineers, by T. Baker, C.E., vol. i. . 1s.
61. ———————— vol. ii. . 1s.
62. ———————— Introductory Sketches of Railway Details, by R. M. Stephenson, C.E. . . . . 1s.
63. ———————— Treatise on the Construction of Agricultural Buildings of every description, by G. H. Andrews, Agricultural Engineer . 1s.
64. ———————— on Motive Powers, and the Machinery of the Steading, by G. H. Andrews, A.E. . . . . . . 1s.
65. ———————— on Agricultural Field Engines, Machines, and Implements, by the same . . . . 1s.
66. ———————— on Clay Lands and Loamy Soils, and the Value of different Lands, by Prof. Donaldson, Government Land Drainage Surveyor . . . . 1s.
67. ———————— on Clock and Watch-making, and on Church Clocks, with illustrations, by E. B. Denison, M.A., vol. i. . . 1s.
68. ———————— vol. ii. . . 1s.
69. ———————— and Practical Treatise on Music, with plates of examples, by C. C. Spencer, Professor of Music, vol. i. . . . 1s.
70. ———————— vol. ii. . . . . 1s.
71. ———————— Instruction for Playing the Piano-Forte, by the same . . 1s.
72. ———————— Treatise (A Manual of the Mollusca) on Recent Fossil Shells, by S. P. Woodward, Assoc. of the Linnæan Soc. . 1s.
73. ———————— Illustrations to Do. 1s.
74. ———————— vol. ii. of the same . 1s.
75. ———————— Illustrations . . 1s.

*** Coloured after nature, *price* 10*s.* 6*d.* *each series.*

76. ———————— Treatise on Descriptive Geometry, with the Theory of Shadows and of Perspective, from the French of G. Monge, by J. F. Heather, M.A. . . . . 1s.
77. ———————— Descriptive Geometry: Illustrations to the same, in 14 plates, atlas 4to . . . . 1s.
78. ———————— Steam as applied to General Purposes and Locomotive Engines, by J. Sewell, C.E. . . . vol. i. . 1s.
79. ———————— Locomotive Engines only, by the same, vol. ii. . 1s.
79*. ———————— Supplementary volume to the above, illustrative of the Origin, Growth, and rapid Developments of the Locomotive Engine . . . . 1s.
80. ———————— Marine Engines, particularly in reference to H.M. Steam Navy, by R. Murray, C.E. . . . . vol. i.
81. ———————— Ditto, and on the Screw, &c., by the same, vol. ii.

82. Rudimentary Treatise on the Power of Water, as applied to drive Flour-Mills, and to give Motion to Turbines and other Hydrostatic Engines, by Jos. Glynn, F.R.S., C.E. . . . 1s.

83. ———— Book-Keeping and Commercial Phraseology, by James Haddon, M.A., King's College, London . . . 1s.

MATHEMATICAL SERIES.

84. ———— and Elementary Treatise on Arithmetic, with a full Explanation of the Theory, and numerous Examples for Practice and for Self-Examination, by J. R. Young, late Prof. of Mathematics, Belfast Coll.: with the Answers at the end 1s.6d.

85. ———— Equational Arithmetic, applied to Questions of Interest, Annuities, and General Commerce: also Formulæ for the Solution of all ordinary Calculations by a simple Equation, by W. Hipsley, of Hull . . . . 1s.

86. ———— Elements of Algebra, for the use of Schools and Self-Instruction, vol. i. by James Haddon, M.A., King's Coll., London 1s.

87. ———————— vol. ii. by the same . . . . 1s.

88. ———— Principles of Geometry; the application of Logic to Geometrical Reasoning, based on the text of Euclid, Books 1, 2, 3. By Henry Law, C. E., vol. i. . . . . . 1s.

89. ———————————— vol. ii., by the same; 4th, 5th, 6th, 11th and 12th Books of Euclid, with illustrative Notes, and a practical application of the various Theorems . 1s.

90. ———— Analytical Geometry, by James Hann, Professor, King's Coll. 1s.

91. ———— Treatise on Plane Trigonometry, by the same . . . 1s.

92. ———————— Spherical Trigonometry, by the same . . 1s.

93. ———— Elements and Practice of Mensuration and Geodesy, by T. Baker, C. E. . . . . 1s.

94. ———— Treatise on Logarithms, vol. i. by Henry Law, C. E. . . 1s.

95. ———— Tables for facilitating Astronomical, Nautical, Trigonometrical, and Logarithmic Calculations, vol. ii. by the same . 1s.

96. ———— and Elementary Treatise on Popular Astronomy, by the Rev. Robert Main, of Her Majesty's Observatory, Greenwich . 1s.

97. ———— Principles and Practice of Statics and Dynamics, by T. Baker, C. E. . . . . 1s.

98. ———— Elements of Mechanism, elucidating the Principles developed by the Science of Mechanics for the elementary and practical Construction of Machines, for the use of Schools and the Student in Mechanical Engineering, by T. Baker, C.E. 1s.

98*. ———————————— with Practical Machines, by the same 1s.

99. The Theory and Practice of Nautical Astronomy and Navigation, by H. J. Jeans, Royal Naval College, Portsmouth, vol. i. . 1s.

100. ———————————————————— vol. ii. . 1s.

These volumes describe the use of the 'Nautical Almanac,' by means of an investigation of the construction of some of the Tables contained therein: they also contain numerous easy Examples,—Rules at length for finding the latitude and longitude and variation of the compass, and also their investigation,—thus rendering it complete, without reference to any other work on the subject.

101. Rudimentary Differential Calculus, in which the Principles are clearly *elucidated*, by W. S. B. Woolhouse, F.R.A.S. . . 1s.

102. Rudimentary Integral Calculus, in which the Principles are also clearly elucidated, by Homersham Cox, M. A. of Cambridge .
103. ———— Collection of Examples of the Integral Calculus, vol. i. by James Hann, Professor, King's College . . .
104. ———————— the Differential Calculus, vol. ii. by J. Haddon, M. A., King's College . . . .
105. ———— and First Mnemonical Lessons in Algebra, Geometry, and Trigonometry, by the Rev. Thos. Penyngton Kirkman, M.A., Rector of Croft-with-Southworth, Lancashire . 1

This volume, which contains more than the usual number of pages, is an excellent accompaniment to the 21 preceding works.

NEW SERIES OF 'LONDON.'

A new Series at 1*s*. each, developing in Ten Sectional Divisions, for the convenience of the Industrial Classes,

THE METROPOLIS OF THE BRITISH EMPIRE AND ITS NEIGHBOURHOOD,

Described and elucidated by an Exposition of its History and Antiquit

INCLUDING

The History of the Corporation of the ancient City of London—its Arts, Tra and Commerce—its Architecture, Club-Houses, Docks, Picture Galleries, Scient Institutions and Public Libraries, Astronomical Observatories in and near Lond and other interesting and useful information, amply described and illustrated.

The following opinion of the whole combined as a volume has been expres by a periodical of the highest standard, devoted to literature and the arts:

"A volume of nearly a thousand closely printed pages descriptive of everything that interest the stranger or the resident, profusely embellished with more than two hundred c fully executed wood-cuts of the principal points of interest in its thoroughfares, and a ne constructed Map by Mr. Lowry, cannot be otherwise than acceptable to the mass of visi to the Metropolis at the present time. When we add that all this is produced at an exceedir moderate cost, we cannot but feel that Mr. Weale's work was suggested by higher than n trade notions,—by a wish, in fact, to be serviceable to all who wanted such services. Through we trace a careful desire to be accurate and a freedom from a mere common-place laudatio certain pet places which are stereotyped for praise, such as the view from Richmond Hill other localities. With such a book as this none but the hypercritical could be dissatisf In going over so large a field, and the vast amount of pains taken, the insignificance of a slips of the pen render them venial. We cannot but feel the superiority of a work of this k to some more ambitious hand-books, which are made up by a paste-and-scissors process, with abundance of quotations from old books, containing mere nominal allusions to places and thir void of all interest but that which the philosophical inquirer may need in noting the misdirec ingenuity of the compiler. Mr. Weale's book takes a higher position than these, and he is ju entitled to higher reward. His volume is a sensible and useful guide."—*Art-Union Jour Sept.* 1851.

1. London.—Section i. The Physical Geography of the Basin of the Thames —ii. Climate—iii. Geology—iv. Natural History—v. Statistics—Spirit of the Public Journals—'Times' Printing-press—vi. Legislation and Government, Municipal Arrangements, Police, Postal Arrangements—Banking—Assurance Offices—Export and Import Duties. *Wood-cuts* of 'Times' Machine . . . .
2. ——— *Architecture*—Remarks on its History—the Tower—Temp

Church—Westminster Abbey—St. Stephen's Chapel—St. Paul's—Churches, including those by Sir C. Wren, Inigo Jones, Sir W. Chambers, &c. 30 *wood-cuts*, interior and exterior of Churches . .

3. London.—Somerset House—St. Paul's before the fire—Almshouses—Arts, Manufactures, and Trades—Tables of Life Assurance Companies, with the Rates of Premiums—Asylums—the Bank of England—Baths and Washhouses—Buildings for the Labouring Classes—Breweries—Bridges—Canals—Cemetery Companies—Club-Houses. 27 *wood-cuts* :

4. ——— Club-Houses—Churches—Colleges—an elaborate account of the Privileges and Constitution of the City of London, a special article—Customs, Custom House, Docks, and Port of London—Royal Dockyards, with plans—Ducal Residences—the Electric Telegraph—Education—Engineering Workshops—the Royal Exchanges, Coal and Corn Exchanges—Coffee Houses, &c. 30 *wood-cuts* of Club Houses, the Docks, and the three Royal Exchanges, plans and elevations . .]

5. ——— Galleries of Pictures.—Succinct account of all the Pictures, with the names of the Masters, in the Galleries and Collections of Lord Ashburton—Barbers' Hall, City—Bridewell Hospital—Thomas Baring, Esq., M.P.—the Society of British Artists—British Institution—British Museum—the Duke of Buccleuch—Chelsea Hospital—the Duke of Devonshire—G. Tomline, Esq., M.P.—Dulwich College—the Earl of Ellesmere—the Foundling Hospital—School of Design—Greenwich Hospital—Vernon Gallery—Grosvenor Gallery—Guildhall—Hampton Court—T. Holford, Esq.—H. T. Hope, Esq., M.P.—St. James's Palace—H. A. J. Munro, Esq.—Kensington Palace—the Marquis of Lansdowne—the National Gallery—National Institution—the Duke of Northumberland—Lord Overstone—Mr. Sheepshanks—Lord Garvagh—Earl de Grey—Lord Normanton—Sir Robert Peel—the Queen's Gallery, Buckingham Palace—Samuel Rogers, Esq.—Royal Academy—Society of Arts—the Duke of Sutherland—Lord Ward—the Marquis of Hertford—the Duke of Wellington—Whitehall Chapel—Windsor Castle, &c. 13 *wood-cuts* . . . .]

6. ——— Gas Works and Gas-lighting in London—Gardens, Conservatories, Parks, &c. around London, with an account of their formation and contents. 21 *wood-cuts* of the principal Conservatories, Gardens, &c. . . . .]

7. ——— Halls, Hospitals, Inns of Court—Jewish Synagogues—Schools, Learned Societies, Museums, and Public Libraries—Lunatic Asylums—Markets—Mercantile Marine—the Mint—Music, Opera, Oratorio—Musical Societies, &c. 17 *wood-cuts* . . . .]

8. ——— Observatories in London and its Vicinity—Observatories and Astronomical Instruments in use at Cambridge and Oxford, with 20 *wood-cuts* of interior and exterior of Observatories, and of Astronomical Instruments . . . .]

9. ——— Patent Inventions in England—Public and Private Buildings of London, criticisms on the taste and construction of them—Houses of Parliament—Prisons, &c. 16 *wood-cuts* . . . . . .]

10 ——— Railway Stations in London—Sewers—Statuary—Steam Navigation on the Thames—The Works of the Thames Tunnel—Water-

Supply to the Metropolis—Excursion to Windsor, with views and plans; plans of the Stables, &c.—The Two Universities of Cambridge and Oxford, with views and plans of the Colleges; and an Index and Directory. 25 *wood-cuts* . . . .]

*** The following gentlemen were contributors to the preceding:

P. P. Baly, Esq. C.E.
G. R. Burnell, Esq. C.E.
M. H. Breslau, Esq.
Hyde Clarke, Esq. C.E.
E. L. Garbett, Esq. Architect.
J. Harris, Esq. C.E.
George Hatcher, Esq. C.E.
Edward Kemp, Esq.
Henry Law, Esq. C.E.
W. H. Leeds, Esq.
Rev. Robert Main, LL.D.
H. Mogford, Esq.
William Pole, Esq.
George Pyne, Esq.
Charles Tomlinson, Esq.
W. S. B. Woolhouse, Esq. Actuary.

NEW SERIES OF EDUCATIONAL WORKS;

OR

Volumes intended for Public Instruction and for Reference:

To be published in the course of 1852.

The public favour with which the Rudimentary Works on scientific subjects ha been received induces the Publisher to commence a New Series, somewhat differe in character, but which, it is hoped, may be found equally serviceable. T Dictionaries of the Modern Languages are arranged for facility of referen so that the English traveller on the Continent and the Foreigner in England m find in them an easy means of communication, although possessing but a slig acquaintance with the respective languages. They will also be found of essent service for the desk in the merchant's office and the counting-house, and mc particularly to a numerous class who are anxious to acquire a knowledge languages so generally used in mercantile and commercial transactions.

The want of small and concise Greek and Latin Dictionaries has long be felt by the younger students in schools, and by the classical scholar who require book that may be carried in the pocket; and it is believed that the present is t first attempt which has been made to offer a complete Lexicon of the Gre Language in so small a compass.

In the volumes on England, Greece and Rome, it is intended to treat History as a Science, and to present in a connected view an analysis of the la and expensive works of the most highly valued historical writers. The extensi circulation of the preceding Series on the pure and applied Sciences amon students, practical mechanics, and others, affords conclusive evidence of t desire of our industrious classes to acquire substantial knowledge when plac within their reach; and this has induced the hope that the volumes on Histc will be found profitable not only in an intellectual point of view, but, which is still higher importance, in the social improvement of the people; for withc a knowledge of the principles of the English constitution, and of those eve which have more especially tended to promote our commercial prosperity a political freedom, it is impossible that a correct judgment can be formed by t mass of the people of the measures best calculated to increase the national welfa or of the character of men best qualified to represent them in Parliament; a this knowledge becomes indispensable in exact proportion as the elective franch may be extended and the system of government become more under the influen of public opinion.

The scholastic application of these volumes has not been overlooked,

comparison of the text with the examinations for degrees, given at the end of the second volume of the History, will show their applicability to the course of historic study pursued in the Universities of Cambridge and London.

1. Outlines of the HISTORY OF ENGLAND, with special reference to the origin and progress of the English Constitution, by Wm. Douglas Hamilton, of University College, with illustrations . . . . . 1s.
2. ————————————, Continuation, bringing the History down to a recent period . . . . 1s.

*** This history is designed to communicate, in an accessible form, a knowledge of the most essential portions of the great works on the English Constitution, and to form a text-book for the use of Colleges and the higher classes in Schools.

3. View of the HISTORY OF GREECE, in connection with the rise of the arts and civilization in Europe, by W. D. Hamilton, of University College . 1s.

"To Greece we owe the Arts and Sciences, but to Rome our knowledge of them."

4. HISTORY OF ROME, considered in relation to its social and political changes, and their influence on the civilization of Modern Europe, designed for the use of Colleges and Schools, by the same . . . 1s.
5. A Chronology of Civil and Ecclesiastical History, Literature, Science, and Art, from the earliest time to 1850, by Edward Law, vol. i. . . . 1s.
6. ———————————————— vol. ii. . . . 1s.
7. Grammar of the English Language, for use in Schools and for Private Instruction . . . . 1s.
8. Dictionary of the English Language, comprehensive and concise . . 1s.
9. Grammar of the Greek Language, by H. C. Hamilton . . . . . . 1s.
10. Dictionary of the Greek and English Languages, vol. i. by H. R. Hamilton 1s.
11. ————————————————, vol. ii. by the same . 1s.
12. ———————— English and Greek Languages, vol. iii. by the same . 1s.
13. Grammar of the Latin Language, by H. C. Hamilton . . . . . . 1s.
14. Dictionary of the Latin and English Languages, vol. i. by H. R. Hamilton 1s.
15. ————————————————, vol. ii. by the same . 1s.
16. ———————— English and Latin Languages, vol. iii. by the same . 1s.
17. Grammar of the French Language . . . . 1s.
18. Dictionary of the French and English Languages, vol. i. by D. Varley . 1s.
19. ———————— English and French Languages, vol. ii. by the same . 1s.
20. Grammar of the Italian Language, by Alfred Elwes, Professor of Languages 1s.
21. Dictionary of the Italian, English, and French Languages, v. i. by the same 1s.
22. ———————— English, Italian, and French Languages, v. ii. by the same 1s.
23. ———————— French, Italian, and English Languages, v. iii. by the same 1s.
24. Grammar of the Spanish Language, by the same . . . . . . 1s.
25. Dictionary of the Spanish and English Languages, vol. i. by the same . 1s.
26. ———————— English and Spanish Languages, vol. ii. by the same . 1s.
27. Grammar of the German Language, by G. L. Strausz, (Ph. Dr.) . . 1s.
28. Dictionary of the English, German, and French Languages, vol. i. by Nicolas Esterhazy S. A. Hamilton . . . . 1s.
29. ———————— German, English, and French Languages, vol. ii. by the same . . . . 1s.
30. ———————— *French*, English, and German Languages, vol. iii. by *the same* . . . . 1s.

MATHEMATICS

FOR

PRACTICAL MEN:

BEING

A COMMON-PLACE BOOK

OF

PURE AND MIXED MATHEMATICS,

DESIGNED CHIEFLY FOR THE USE OF

CIVIL ENGINEERS, ARCHITECTS, AND SURVEYORS.

BY OLINTHUS GREGORY, LL.D., F.R.A.S.

THIRD EDITION, REVISED AND ENLARGED.

BY HENRY LAW,

CIVIL ENGINEER.

CONTENTS.

PART I.—PURE MATHEMATICS.

PART II.—MIXED MATHEMATICS.